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L. Agassiz

QUARTERLY JOURNAL

OF

MICROSCOPICAL SCIENCE.

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VOLUME III.

With Illustrations on Wood and Stone.

LONDON:

SAMUEL HIGHLEY, 32, FLEET STREET.

1855.

LONDON: PRINTED BY W. CLOWES AND SONS, STAMFORD STREET.

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LONDON:
Printed by W. Clowes and Sons,
Stamford Street.

QUARTERLY JOURNAL

OF

MICROSCOPICAL SCIENCE.

ORIGINAL COMMUNICATIONS.

On the ENLARGEMENT *and* MULTIPLICATION *of the* IMAGES *of* OBJECTS, *when viewed by the Light admitted through small Apertures; and on the* DIASCOPE, *a new Optical Instrument.* By JOHN GORHAM, M.R.C.S.L., &c.

(*Continued from Vol. II., page* 234.)

IT has been before noticed that less attention has been bestowed upon the investigation of objects that lie near at hand, within an inch or two, we will suppose, of the eye, than upon objects which are placed at a considerable distance from it, that, for example, of as many furlongs. I have also endeavoured to show that small circular perforations made in a card, and rendered semi-transparent, constituted in themselves objects well adapted to illustrate the magnifying power of short spaces, by presenting a rapid and palpable enlargement of the visual angle to the eye; and, lastly, a series of phenomena has been described, which resulted from viewing small figures held close to the eye *in front of* such apertures, and rendered visible by the light admitted through them.

The whole subject arranges itself therefore under two distinct divisions, which comprise:—1. An examination of the images formed by viewing objects held *in front of* small apertures; and 2. An examination of those images which result from placing the objects *behind* the apertures.

1. Of images formed when the eye and the object are both on the same side, that is, in front of the apertures.

We have already seen that when bodies not exceeding the diameter of the pupillary opening of the eye are held in close proximity to the visual organ, and are then examined by the light admitted through small inlets about the fortieth of an inch in diameter, their images become *magnified*, *multiplied*, and *inverted;* and further, that they are illuminated with light

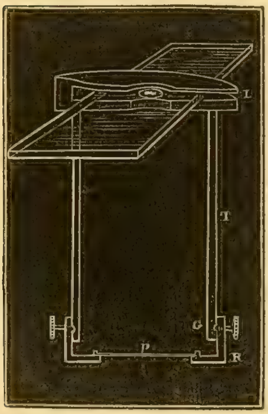
of an intensity varying with the number of apertures employed to render them visible.

This light, be it observed, is always simply transmitted; never being reflected nor refracted by the intervention of glass, or of any other substance having catoptric or dioptric effects. The apparatus required in these experiments therefore is essentially very simple and uncomplicated, consisting indeed of a mere short tube open at one end, and having a plane, perforated with small holes to admit the light, at the other; while the object to be examined is applied at the open end, and held as close to the eye as possible. Hence a pill-box and a narrow slip of glass constitute all that is really necessary to explain the laws which are in operation, and to give an idea of the phenomena which are involved in their successful application.

From the remarks made in a previous section, it is obvious that these phenomena are owing to the *size*, and to the *intervals* of the apertures themselves, and to their *distance* with respect to the eye. Thus their size should be the one-fortieth of an inch,—their intervals the one-tenth of an inch,—and their distance from the eye from one to two inches. If these conditions are not fulfilled, the images become either undefined or dimly illuminated; but when they are strictly observed, the combinations, which an instrument constructed upon such principles is capable of presenting to the eye, are very beautiful.

But a mere tube of pasteboard, however well it might answer for a first experiment, is inefficient, for it is difficult to retain the slip of glass in its proper position between the tube and the eye. It was essential therefore to construct a small instrument of some more solid and durable material, such as wood or ivory, with which experiments might be conveniently performed.

Fig. 14.



This instrument consists of a tube, T, one or two inches long, and about one inch thick, expanding at the end to which the eye is applied into a circular lip, L, which is about one inch and a half in diameter, while that of the round opening in its centre is about half an inch. This end is provided with a slit sufficiently large to permit a thin narrow slip of glass, about an inch broad, to slide easily through it, as shown in the figure. The other end has a circular rim, R,

which revolves in the groove, G, and to this rim is attached a second rim, *r*, which is provided with a female screw, and this secures any circular plane of apertures, *p*, we may choose to insert, at the same time that it admits of its revolution.

A series of objects, either painted or mounted on glass slides, can thus be examined at one end by the light admitted through perforated planes at the other. As such an optical contrivance is a mere conductor of the light directly from the apertures to the eye, while at the same time it excludes all the extraneous rays, it may not inaptly and for convenience' sake be denominated a *diascope:* a term derived from the two Greek words, δια, through, and σκοπεω, I view. And when it is used for the purpose of multiplying images, it may be called the *multiplying diascope.*

The circular planes containing the apertures are made of thick pasteboard, perforated with a needle at intervals of the one-tenth of an inch as before stated; and the openings may be arranged in a variety of combinations, as shown in the patterns from one to six, page 225, of the last paper.

Here let us notice that the round form of the images, depicted on the retina when examining small apertures in this way, is determined by the shape of the pupillary opening of the eye rather than by that of the apertures themselves. Hence it is always circular whether these be *round*, *triangular*, *square*, or altogether *irregular* in outline. This can easily be proved by perforating cards with triangular or square needles. The openings thus made when brought very near to the eye always appear circular. A little reflection will show that this is a necessary result, inasmuch as the outermost rays of the rapidly-diverging cones are intercepted by the *iris*, while the more internal rays pass on through the pupil, thus receiving their circular form.

Hence if the pupil be widely expanded the discs will be large, and *vice versâ*, but nevertheless always perfectly round.

Let us now take a circular plane, presenting a combination of perforations arranged as to colour and relative position as in the outline, No. 4, page 225, of the last paper; and let us notice what kinds of images are presented to the eye when small bodies are examined by the light transmitted through them.

Holding the instrument to the eye with a view to examine the apertures, we observe that the smallest particle of dust, or film of mucus, happening to exist on the surface of the transparent cornea, is immediately detected; and although such bodies have no definite shape, they are to be recognised interfering with the transparency of the discs, and forming an

opaque spot or streak which occupies exactly the same position in each. Similar results are obtained if a small dot, no bigger than a pin's head, be made on a slip of glass with Indian ink, and introduced into the eye-piece of the diascope. The dot now appears multiplied, and as many images of it are seen as there are apertures by which it is made visible.

In like manner if a small semicircle be painted on glass, its images will be multiplied, but each image will be seen inverted, and will appear as a black body on an illuminated and coloured ground.

And if a small triangle, or any other figure of definite shape, be cut from a piece of black paper, and if the *opening* thus made be examined in the same way, a number of illuminated and coloured triangles will be seen on a black ground.

It is when transparent figures are made according to this last method that really beautiful combinations may be produced. But here, in order to insure success, it is necessary that the transparent openings should never exceed in size the pupillary aperture of the eye, fig. 16. Hence they should always be made within the limits of a circle, the 0·18 of an inch in diameter, fig. 15; this being the mean of the greatest and least

Fig. 15.

Fig. 16.

expansion of the pupil. If such transparent figures are made greater than this, the margin of the pupil will obstruct some of the external rays, and the outline of the image will thus be lost or badly defined. If, on the other hand, they are less, the quantity of light admitted into the eye will be too small, and the images but feebly illuminated.

Such openings used as objects are to be considered as little else than artificial pupils, modifying the shape and contracting the size of every cone of light which is admitted into the eye from small apertures.

When one of these transparent openings is held close to the eye, and examined with common diffused light, it becomes altogether invisible; but, when it is viewed by the aid of a pencil of light from a small inlet, its outline is well defined and much magnified; and the disc of the inlet, which would otherwise be circular, is replaced by the pattern we may choose to give to the transparency.

And if the pupil of the eye itself, obliterated, as it often is, from disease, have a small portion excised from it, as in

the operation for artificial pupil, the newly-formed opening will appear inverted and multiplied in the same way; and each image, instead of being circular as it is in the healthy eye, will be seen to resemble the figure of the new and distorted pupil.

But in order to demonstrate the images which this instrument is capable of presenting to the eye in the most satisfactory manner; instead of cutting holes in pieces of black paper, a series of figures having a transparent body and a black outline may be painted on glass with Indian ink. For this purpose round patches of ink, about the size of a fourpenny piece, should be laid on the centre of each glass slip with a camel's-hair pencil; and, when dry, transparent figures of the required shape and dimensions can easily be made by erasing a portion of the ink with a finely-pointed and slightly-moistened wooden style.

The forms of such transparencies will suggest themselves to the ingenuity of the reader, but a few are subjoined by way of example (figs. 18 to 33).

Fig. 18. 19. 20. 21. 22. 23. 24. 25.

Fig. 26. 27. 28. 29. 30. 31. 32. 33.

Fig. 18. Regular hexagon.
,, 19. Hexagonal star.
,, 20. Rhomb of 60°.
,, 21. Curved triangle.
,, 22. Ditto.
,, 23. Trefoil.
,, 24. Circle.
,, 25. Concentric circles.
,, 26. Triradiate star of 120°.
,, 27. Straight lines intersecting at 60°.

Fig. 28. Two semicircles.
,, 29. Triangle and semicircle.
,, 30. Curved and straight lines intersecting at 60°.
,, 31. Three lines intersecting at 60°.
,, 32. Two curved lines intersecting at 60°.
,, 33. Two angles of 60° intersecting.

Such forms arrange themselves into two groups; those, for instance, which are entire in themselves, and which constitute elegant designs by their *multiplication* and the shifting of their relative position (figs. 18 to 25), and those again which are imperfect figures, but which produce entire compositions of great beauty by their *combination* (figs. 26 to 33).

As the apertures are arranged in lines which cross each other at angles of 60° and 120°, the outlines of the transparent figures should bear the same angular relation. Thus the modifications of the equilateral triangle, the rhomb of 60° and 120°, and the regular hexagon, a few of which are given in the above examples, are well suited for the purpose.

When a transparent hexagonal star (fig. 19), slid into the eye-piece of the instrument and brought close to the eye, is examined by the light admitted through a combination of apertures, that, for instance, marked No. 4, at the 225th page, placed at the other end, the images of a number of stars are apparent. These stars are seen to change their relative position with every movement, however slight, of the revolving plane. Sometimes they are observed to touch each other by one ray, at others by two, while in intermediate positions the rays alternate. The patterns which are thus formed are as variable as the parts into which a circle can be divided. They are shown in two of their phases of revolution in the 4th and 5th figures of Plate VIII., Vol. II.

The concentric circles, fig. 25, thus multiplied display themselves with good effect. Their appearance is represented in the 6th figure of Plate VIII., which is produced by using the arrangement of apertures marked No. 5, page 225.

But the combinations effected by the mutual coalescence of the images of the imperfect figures into one entire composite form are the most curious. Thus if the three-rayed star, fig. 26, be examined, its images will be seen either to alternate (fig. 9, Plate I., Vol. III.), or to resolve into one hexagonal reticulation with a dot in the centre of each mesh, as shown in fig. 10, Plate I., Vol. III. And the images of the figure, composed of the straight and curved lines, fig. 30, unite into many fresh devices; two of which are copied in the figures 7 and 8, Plate I.

But it is needless to multiply examples, as those which have been already given will doubtless have sufficed to explain the construction of the instrument, and one of the purposes at least to which it may be legitimately applied.

Hitherto we have confined our attention chiefly to the *multiplication* of the images of *artificial* objects prepared expressly for the purpose, and viewed by the aid of the light admitted through small apertures.

We are now to consider how the images of *natural* objects are *magnified* by the same means.

Here let us notice, *in limine*, that we are not about to institute a comparison between two optical instruments, the eye and the achromatic microscope, which although they are con-

structed on the same principles are yet totally different as to their uses. The healthy visual organ, itself a perfect instrument, "converses with its objects" at almost all distances, and assists the other senses in becoming acquainted with the form, position, and magnitude of material substances. The microscope, on the other hand, all but a perfect instrument, enables us to see clearly and to examine certain objects, which from their small size and without its aid would be indistinct, if not altogether invisible. It is restricted to the small size and the short distance of its objects, and from its very construction it has magnifying powers which the eye neither possesses nor requires. If the eye were endowed with these, therefore, to the exclusion of its self-adjusting properties, whereby it discerns common objects in the ordinary way at great and small distances, it would be rendered comparatively useless as a visual organ.

Hence it were folly to attempt to invest this organ with functions, the possession of which would subject its owner to the greatest inconvenience. An exemplification of this position occurs to me in the case of short-sighted persons.

When therefore we find ourselves enabled by a carefully-devised experiment to detect, with the naked eye, certain configurations upon or within an object which, we may suppose, has never before yielded an image at all excepting through the medium of a lens, we are not to imagine that we are thereby infringing on the domains of the microscope, which being constructed for this very purpose would present us, perhaps, with an image ten thousand times as large and distinct. But putting this instrument altogether out of consideration, and throwing aside all extraneous assistance, we are the rather to consider how the eye, which has certain limits to distinct vision for short distances, can yet adjust itself for spaces still smaller, and in so doing become converted into a kind of natural magnifying glass.

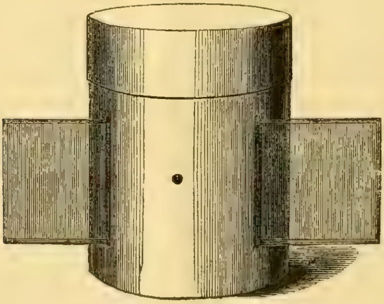
We have now therefore to turn our attention to certain microscopic objects, which are to be examined and resolved without a lens of any description; and we are stimulated to an investigation of this kind by recollecting what has been already attained with respect to the magnitude of the images of small apertures themselves, when placed under circumstances the most favourable for their inspection. Amongst these we cannot fail to have noticed at least two conditions necessary to be fulfilled in such investigations, viz.—First, that the object be held very near to the eye; and secondly, that every ray of light, excepting what is required to illuminate the object, be carefully excluded. The first insures an

enlarged image, whilst the second prevents a too great contraction of the pupillary opening. Hence the necessity for examining objects through small darkened tubes, and hence, too, the necessity for closing the eye which is not engaged in exploring.

Again, we must not overlook the fact, that in using a small aperture for the purpose of examining any transparent substance there are two methods which may be employed. By the one, *the object is viewed through the aperture;* by the other, the *aperture is viewed through the object.* The former has been almost always adopted by the curious, the latter scarcely ever. It is capable, however, as these papers show, of eliciting so many phenomena peculiar to itself, that I am surprised it has not been frequently used, and the results carefully investigated. Each of these plans throws a different picture on the retina of the eye, and of this the transparent animal membrane chosen for the following experiments will afford, when examined in both ways, abundant exemplification.

For the purpose of presenting very small objects, mounted on microscopic slides in the usual way, before the eye at small distances behind a minute aperture, and to exclude the surrounding rays of light, I took an upright box of pasteboard about one inch and a half deep, and one inch and a quarter in diameter, and having cut a couple of slits through one of its sides sufficiently large to admit of a slip of glass an inch broad sliding to and fro, I made two small apertures opposite to each other, the first the one-thirtieth of an inch, and the second the one-fourth of an inch in diameter; and these were so disposed, that when the glass slip with a small object

Fig. 34.



mounted on its centre was introduced through the slits, the two apertures and the object were all in one straight line; while the slide was about a quarter of an inch behind the smaller opening, see fig. 34.

With this simple apparatus I could examine very small transparent objects at pleasure, either by the light of the sun or of a taper. Whilst, however, it has been thought better to notice the dimensions of the apertures, &c., for the convenience of others who might wish to repeat the experiments, it must not, by any means, be supposed that they are the best adapted to insure success, or that better could not be devised.

Having been engaged in the preparation of a series of dissections of the *compound cornea* of the eye in insects, I naturally subjected one of these beautiful objects to the first experiment in my *lens-less microscope*. Here, however, for the information of those who may not be conversant with these objects, or the peculiarities of their structure, it may be remarked that the roundish, prominent, transparent elevations observed, generally one on each side of an insect's head, constitute the membrane in question. This membrane forms at once the defence and the covering to the delicate parts in the interior of the eye, as well as the transparent medium by which the light is admitted into this tiny organ. It is analogous, moreover, to the transparent cornea of the eye in the higher classes of animals in being transparent, composed of several firmly-adhering layers, and forming the outermost of all the coverings of the eye. But it is altogether dissimilar in this respect, that it is found to consist of an immense number of facets or little pieces lying, side by side, like fine mosaic; and which from being of a regular hexagonal shape, and arranged in perfect order, present when examined under the microscope an appearance like a honeycomb. Hence it has received the name of *compound cornea.*

The eye of the large insect, called the dragon-fly, is recommended for a first trial in dissection, because it is not only very large but exceedingly beautiful. The *compound cornea* is at once separated from the rest of the eye with a pair of finely-pointed scissors, and the dark thick pigment which fills the inside is then washed away by soaking in a tumbler of cold water for an hour or two, and then using a camel's-hair pencil. To procure it in a perfectly clean and transparent state, however, it is better to wash and rewash it after maceration for two days in frequently-changed cold water. Then, while still moist, let small circular pieces be excised with a small punch, and pressed immediately between two slips of glass. In a few days they will have become dry and flat, and may then be mounted in what is called the dry way, as if for the microscope.

I wish it was in my power to convey to my readers an idea of the great beauty of one of these specimens; to say nothing

of the wonderful arrangement whereby upwards of twelve thousand planes, each a perfect hexagon, are packed in a bit of membrane scarcely so large as half the little finger nail. "I have often," says the celebrated Leeuwenhoek, "made repeated dissections of the eyes of various kinds of insects, merely on account of the pleasure the contemplating them afforded me."* But few, however, seem inclined to investigate these subjects for themselves, trusting rather to that second-hand kind of knowledge derivable from books. This distaste for exploring the works of nature may possibly, in some instances, commence with the limited resources of the pocket; the very preparation of a microscopic object involving the necessity for a costly instrument wherewith to investigate it. If, however, I shall succeed in pointing out certain beauties peculiar to the compound cornea in the eye of the insect, which may be discovered with the naked eye, and without a microscope, this membrane will have become invested with a new interest, and thus others may be stimulated to a like inquiry. But to return. Having inserted a slide containing a circular section of the eye of the dragon-fly in the box prepared for the purpose, I proceeded to examine it. Recalling to mind, however, that each of the hexagonal facets is barely the six-hundredth of an inch across, and that many hundreds of such facets are contained in the smallest section, it was much to anticipate that such a structure should be resolved by a process so simple; and when on viewing the membrane, by looking at it through the small aperture, while a lighted candle was held nearly close to the larger one, it presented a semi-opaque and altogether homogeneous appearance, I had almost concluded that my efforts were frustrated. To overcome the difficulty was reserved, however, for a future trial. Now if, instead of a candle, a small wax taper be used, and if this be held at the distance of from five to nine feet, rather than close to the large aperture, a beautiful sight presents itself. Instead of the flame of one taper, there are exhibited the miniature images of the flames of many tapers; and these are not only very definite in their outline so as to be immediately identified, but they are arranged at regular intervals. But, what is still more curious, each image, except the central one, is seen to be composed of the colours of the prismatic spectrum,—violet, indigo, blue, green, yellow, orange, and red; of which the extreme tints are so disposed that the blue portion in each image is always nearest to the central or colourless flame, and the red the most remote from it. Hence the blue and the red tints alternate in concentric

* Leeuwenhoek, vol. ii. p. 341.

circles. When the images which are most distinct, for those near the margin look fainter, assume in the aggregate the form of the hexagonal star, which they not unfrequently do, the appearance is striking and uncommon, see fig. 11, Plate I.

The simplicity of the process by which such a spectacle is produced, together with the novelty of the sight itself, did not tend, of course, to diminish the sense of its gorgeousness; and I was delighted to find a natural multiplying glass in a tissue, which had already contributed so much to my admiration and wonder when examined under a compound microscope.

On viewing the sun in the same way, each small and perfectly circular image presented the rainbow tints in the same order, as in fig. 12, Plate I., and the multiplied images of the pale moon were scarcely less beautiful.

I may remark, in passing, that the taper flame and the image of the moon were seen through a specimen mounted in Canada balsam; but the rays of the sun were less distressing to the eye when examined through a specimen mounted in the dry way.

Thus, although I had not, in this experiment at least, succeeded in rendering visible a magnified image of each hexagon in outline, which indeed was the object of my research, I had, in effect, resolved the reticulated structure of the membrane; for in this way only could the peculiarities of a multiplying medium have presented themselves. The interval between each image served, moreover, to indicate the apparent enlargement of each facet, and thus to give a notion of the magnifying power of short spaces.

Still bearing in mind the comparatively enormous magnitude imparted to images on bringing the objects which produce them very near to the eye, and recollecting that the image of a mere needle-puncture seen at half an inch is magnified no less than a million times, it was difficult to renounce the idea of the practicability of defining the hexagonal lattice-work of an insect's eye with the naked eye, and without the assistance of a material lens.

In the former attempt the membrane seemed too opaque to disclose its minute internal configuration, a specimen was therefore now mounted in balsam to increase its transparency. This, however, did not succeed; on the contrary, it had become so indistinct that its structure could now be scarcely made out even with a microscope. In order to define the hexagons it was evidently necessary to colour the membrane. A few specimens were macerated, therefore, for four days in a decoction of logwood, and then carefully dried and mounted

in balsam. In this way they were rendered sufficiently diaphanous to transmit a strong light from the sun without injuring the eye, and their reticulations were not obscured

Having prepared the object, it was necessary to decide upon the distance from the eye best suited for examining it; and as the nearest position would insure the largest image, this was accordingly adopted. The mode of illumination also required consideration, in order that the light should be of such intensity as to make the object visible without dazzling or injuring the eye. The quantity of light received by any object is often measured with an instrument invented for the purpose, called a *photometer;* but a box with small apertures pierced through the bottom might be shown to constitute a good and efficient substitute for such an instrument. For it is to be inferred from the remarks contained in the sixth paragraph, that when a small object is examined by the aid of the pencils of light admitted through such apertures, it is illuminated by the sum of their intensities. Hence the quantity of light thrown upon the object will be regulated by the number of the apertures, being very nearly proportional to them: that is to say, the intensity from two apertures will be nearly twice as great as that from one.

By varying the number of apertures, therefore, we can regulate the illumination of the object with the greatest nicety. It follows that there is no better way, perhaps, of exploring minute objects with the naked eye, than by holding them, mounted on a slide of glass, as near to the eye as possible, and examining them by looking at them from the inside of a small box through apertures made in the bottom, and which are covered with tracing-paper, by the aid of a strong light.

And this is effected by using the little instrument, to which I have ventured to give the name of *diascope.*

Thus all the conditions were fulfilled; for, 1, the object was rendered sufficiently transparent to transmit the rays of light freely, and sufficiently opaque to prevent the solar rays dazzling the eye; 2, it was coloured to make all its parts visible; 3, it was brought sufficiently near to the eye to be enormously magnified; and 4, all extraneous rays of light, those which were not immediately concerned in the illumination of the object, were shut out. It remains to be noticed that the experiment was crowned with success; for, on examining the membrane by the direct rays of the noonday sun, the whole of its area appeared reticulated, and several *well-defined hexagons were seen in its centre.* While, as a red tint had been communicated to the specimen, its reticulations were most easily discerned in the red discs, inasmuch as the tints of all

substances are most brilliant when viewed in light of their own colour.

By way of recapitulation, I shall beg to sum up with the following remarks:—

1. When small bodies are brought very near to the eye, their images are magnified, just as images of larger objects when seen at a distance are diminished, and by the same law.

2. The apparent magnitude of objects depends on their visual angle.

3. The visual angle, for short distances, may be well illustrated by employing a small circular disc of light.

4. A minute circular disc of light is procured by perforating a card with a needle, through which the light is then permitted to pass.

5. A sewing-needle, of the size marked No. 6, produces an aperture about the one-fortieth of an inch in diameter.

6. In order to examine the light which is transmitted through such an aperture, all extraneous rays should be excluded; hence the plane in which the opening is made should be placed at the end of a tube.

7. The pencil of light admitted through an opening of this kind, held within an inch or so of the eye, consists of rapidly-diverging rays falling upon the cornea. Some of these are entirely lost, others are intercepted by the iris, while the remainder pass on through the pupil, which communicates to the image formed on the retina its circular form.

8. Whether the small aperture itself be round or triangular, square or irregular, in form, provided its area do not much exceed that of a circle the one-fortieth of an inch in diameter, its image is always circular.

9. When more than one aperture is used, and these of different tints, secondary colours result from the overlapping and blending of the images of the primary.

10. If the three primary colours, *yellow*, *red*, and *blue* are used, their images, which overlap in pairs, produce orange, violet, and green light; and when the images of all three blend white light is the result.

11. When a small transparent object is held *close* to the eye it is altogether invisible.

12. But its outline is immediately determined by the light transmitted through one of the small inlets above described, and it is then seen to be not only *magnified* but *inverted*.

13. The image becomes much more distinct when more than one aperture is used, for the intensity of light by which it is illuminated is thereby increased, being almost in a direct ratio with the number of the openings which are employed.

14. The pencils of light which are used for this purpose not only illuminate the object, but intersect in their passage through it, producing as many images as there are apertures.

15. Hence, when a small object is examined by the light admitted through small apertures, it will appear *magnified*, *inverted*, *multiplied*, and illuminated with variable degrees of intensity.

16. The apparent magnitude of an object varies with the distance of the source of light by which it is rendered visible; when this recedes, the pencil of light has less divergence, and the object appears smaller; when, on the other hand, it approaches the eye, the visual cone has a rapid expansion, and the object *still held in the same position* appears magnified.

17. All these effects are demonstrable by using artificially-prepared transparent figures, the dimensions of each of which do not exceed the diameter of the pupillary opening of the eye.

18. It is probable that the minute structure of many natural transparent objects may be recognised in the same way. The hexagonal facets in the eye of the dragon-fly certainly can.

19. These phenomena are, for obvious reasons, but imperfectly discriminated by short-sighted persons.

20. And, finally, it should be noticed that the investigations resulting in the phenomena described in these papers were commenced, and have been conducted throughout, for the specific purpose of testing the power of the naked eye in concentrating the rapidly-diverging rays of light, proceeding from bodies when held at very short distances from it unaided by a lens; and from these inquiries it would appear, amongst other results, that the magnifying power of the eye is limited by the magnitude of the visual angle on the one hand, and by the intensity of light on the other. If the visual angle be too large, the rays are not sufficiently refracted by the humours of the eye to converge to a focus, and form an image on the retina; and if too small, the image is reduced to a mere point. The exact amount of divergence of the rays, therefore, for any individual eye lies somewhere between these two extremes. Again, however nicely adjusted the visual angle may be to the refractive powers of the eye, if the light be too strong the pupil becomes so contracted that only the innermost rays are admitted; while, if it be of small intensity, the object is so dimly illuminated as to be scarcely visible. If, then, whilst a small object is held very near to the eye, so as to insure a rapid divergence of the rays proceeding from it, the pupil can be dilated by the small quantity of light which is used, and to which like a photometer it immediately responds, so as

to admit as large an angle as the lenses of the eye are capable of refracting, at the same time that the object is rendered distinctly visible, then, under such circumstances, we have arrived at the utmost limit to the available magnifying power of the eye. These conditions are fulfilled in the *diascope;* which may be defined to be *an instrument which enables us to develop the microscopic power of the eye by retaining an object close in front of it at one end, while it is examined by the light admitted through small apertures at the other.**

With such a simple optical instrument, altogether destitute of glass, a series of images may be presented which have never before been seen with the naked eye; and by its use we are led to a legitimate conclusion, capable of direct proof, that when a transparent figure is held very near to the eye for the purpose of magnifying it, if an image is seen at all, its size will bear an inverse ratio to the intensity of light by which it is made visible.

In my next communication, which will embody the second part of the subject, I shall beg permission to describe and delineate another set of forms distinct from those which have been noticed in this, and which are produced by substituting straight or circular very narrow apertures of light for the perforations. With such apertures, figures are seen as in perspective, lines appear expanded into planes, and these are multiplied into solids, which, from being of an ethereal brightness, bear a resemblance to models of regular geometric solids of pure glass.

On the Spiral Threads *of the Genus* Trichia. By Frederick Currey, Esq., M.A.

If anything were wanting to show the extent of the field of research, which is open not only to the student but even to the more advanced inquirer in botanical microscopy, it would be sufficient to direct attention to some of the many points in vegetable anatomy upon which the opinions of observers not only differ from one another, but are so utterly and diametrically at variance, that if the one side be right the other must be altogether wrong. Commencing upon the threshold of vegetable life, opinions are still divided as to the structure of the primary membrane of the walls of young cells, Mulder and Hasting contending that the young cell-membrane is pierced like a sieve, whilst Von Mohl asserts that it is com-

* This instrument may be procured at Mr. Highley's Scientific Library, 32, Fleet-street, London.

pletely imperforate. Again, the question of the mode of growth of the thickening layers (that is, whether they are deposited upon the outer or inner side of the primary membrane), although considered by some botanists to be quite decided, has lately been discussed at some length in a new work by Dr. Schacht,* which shows that the subject is not yet exhausted. The apparently fibrous structure of many *liber-cells*, the nature of the milk-vessels, the connexion between spiral and reticulated vessels, the structure of the chlorophyll granules and starch, are all matters upon which our present knowledge must be considered imperfect. A long list might be placed before the reader of questions respecting vegetable structure, upon which the opinions advanced upon the one side are flatly contradicted on the other. Without multiplying instances, I may mention the question of the origin of the embryo in phænogamous plants as one peculiarly illustrative of the point to which I have alluded upon this question. This question, which although physiological in its import, can only be decided by anatomical investigation, embraces two parties whose views are hopelessly irreconcileable ; yet each side is equally positive. Each party asserts that they have *actually seen* that which they describe, which it is hardly necessary to remark is just as impossible as that a thing should be both black and white. Schleiden alleges that he has set the matter at rest by his investigations, and established an incontrovertible theory ; Von Mohl states that Amici has destroyed Schleiden's theory at one blow, and that the matter is quite settled in its principal features *the other way*.

The spiral threads, which it is the object of this paper to discuss, hold a conspicuous place amongst disputed vegetable structures, so far at least as relates to the variety of the opinions entertained respecting them. The genus *Trichia* constitutes a tribe of minute fungi, growing principally, in fact almost exclusively, upon rotten wood, and generally of a yellowish or tawny colour. They belong to the order of the *Gasteromycetes*, in which the spores, which are often intermixed with hairs or threads, are developed in the interior of a case, termed a *peridium* or *sporangium*. They form part of the sub-tribe *Myxogasteres*, in which the plants first appear in the form of a slimy mucilaginous *stratum*, out of which at a later period the spore-cases are developed. The different species of *Trichia* grow in various ways ; in *T. pyriformis* the *peridia* are joined together in a fasciculate manner, in *T. clavata* they are scattered at small distances from one another,

* Beiträge zur Anatomie und Physiologie der Gewächse, by Dr. H. Schacht. Berlin, 1854.

in *T. chrysosperma* the *peridia*, although quite distinct, are so densely aggregated as to cover completely the spot upon which they are spread, in *T. serpula* the *peridia* are flexuous, creeping, and irregular in shape. When the *fungus* is mature the *peridium* bursts, and the spores in its interior are discharged. It is generally supposed that one purpose for which the threads are designed is to assist in scattering the spores, for their elasticity is very great. If a specimen of *Trichia* be examined immediately after the bursting of the *peridium*, the threads are seen protruding through the fissure and apparently struggling for egress; when viewed through the microscope at this period with a low power, they have a slow waving sort of motion, not unlike that of the threads of the *Oscillatoriæ;* if the whole of the mass of threads be extracted with a needle it appears like a small fragment of yellow wool. When a minute portion of this yellow flocculent mass is examined moist, under the microscope, with a power of about 200 diameters, it is seen to consist of narrow delicate fibres having fine spiral markings covering the whole of the walls. A reference to fig. 1, Plate II., which shows a fibre of *Trichia chrysosperma*, will give a general idea of this spiral appearance; and it is with regard to the nature of these threads, and the cause of their spiral appearance, that so much difference of opinion exists. Corda claims to have discovered these threads, which he calls spiral-fibrous-cells (*spiral-fiber-zellen*); but they were observed about the same time by Mr. Berkeley, and in fact could not fail to have been noticed by any person happening to examine a fragment of the woolly mass with a moderately good microscope.*

Corda, in a letter addressed to Baron Humboldt, and which was published at Prague in 1837, enters at some length into the nature of these spinal-fibrous cells, and considers them to be analogous to the elaters of the Jungermanniæ. After admitting that weighty objections might be raised against the comparing of them with the spiral cells found in the walls of the capsules of the Jungermanniæ, and in the *sporangia* of the Equisetaceæ, or with those in the leaves of *Sphagnum*, he comes to the conclusion that no unprejudiced person can deny the following facts with regard to their structure:—

1. That they consist of a simple or stratified cellular membrane.

2. That this membrane encloses one or more spiral fibres.

3. That the spiral fibre is of a rigid fibrous structure.

He then traces the spiral form through the cells of

* The structure seems to have been *first* noticed by Hedwig, Obs. Bot. Fasc., i. p. 14; and next by Kunze, Myc. Heft II., p. 94.

Nepenthes and the vessels of the Coniferæ up to the perfect spiral vessel, and afterwards the degeneration of the perfect spiral vessel into the "worm-shaped bodies" (wurmföninge körpen) in the tubers of the Orchideæ and in other plants, concluding with an expression of opinion that these *spiral fibrous-cells* must be considered as imperfectly developed forms of the spiral vessel.*

Soon after the publication of Corda's observations, Mr. Berkeley noticed the threads in question in the Annals of Natural History, and stated that so far as he had investigated them they differed in no respect from the spiral vessels of the higher plants.

The next observer was Schleiden, whose opinion was entirely opposed to the *fibrous* theory of Corda and Berkeley. He (Schleiden) says that he has reason to believe that no spiral fibre exists, but that the threads are flat band-like cells spirally twisted, thus attributing the spiral appearance to the existence of a twist in the cell-wall. Dr. Schacht in his admirable work, "Die Pflanzenzelle," subscribes to Schleiden's opinion, and states that he was long ago convinced that no spiral band exists, but that the appearance by which Corda was deceived arises from the torsion of flat thread-like cells. According to Schacht, Dr. Klotzsch found that in an early stage of the threads no spiral appearance was visible.

Mr. Henfrey in a late communication to the Linnæan Society has given the result of his own observations, and expresses a very confident opinion as to the existence of a spiral fibre; so much so that, having the greatest faith in the observing powers of Schleiden and Schacht, he is driven to doubt the goodness of their instruments.

A careful examination of the threads of several species of *Trichia* has led me to a conclusion different from those of the observers above referred to; and I will proceed to state the objections which appear to me to exist against the theories of Corda, Berkeley, and Henfrey on the one side, and of Schacht and Schleiden on the other. There is no substantial difference between the views of Corda and Berkeley, who agree in the main point of the existence of a spiral fibre. In the first place the non-existence of spiral vessels in other genera of fungi † (*Batarrea perhaps* excepted) affords some *primâ facie* ground for supposing that the organisms in question do not

* Corda's expression is, "*Erstarrte Traumbild*," meaning literally, "*a vision become rigid.*"

† Bonorden, in his 'Handbuch der Allgemeinen Mycologie,' states, that a spiral fibre exists in *Arcyria punicea*; but this, I apprehend, is a mistake.

contain fibres. It does not seem probable that spiral vessels, which have always been considered a type of advanced organization, should be altogether wanting in the vast tribe of the *Hymenomycetes*, that they should disappear at the close of the series of the higher *Cryptogamia* to come to light again in the lower scale of the *Gasteromycetes:* this argument of course is by no means conclusive, but in a question where so much difference of opinion exists it is deserving of consideration, and cannot safely be altogether rejected. Again the shape of the *Trichia*-threads exhibits a great departure from the ordinary form of spiral vessels; Schacht, in the work to which I have alluded, asserts that spiral vessels are seldom branched, and mentions two instances as cases of unusual occurrence, in which branched spiral vessels have been observed: the accuracy of this statement has been questioned, and it has been alleged that spiral vessels are frequently branched, especially in endogenous plants; but whichever view be correct, I apprehend that a branched spiral vessel must be considered abnormal in form, and consequently when we find, as was long since noticed by Corda, that the *Trichia*-threads are very frequently branched, and sometimes to an extent almost amounting to reticulation, this fact must be admitted to weigh something in the scale against the probability of the existence of fibres.

Another objection arises from the rapidity with which the *Trichia* are matured. It is well known that the *Myxogasteres*, as well as some other of the *Gasteromycetes*, grow with astonishing rapidity. *Batarrea gaudichaudi*, a South American species, attains its full size in a few hours; the developement of *Phallus impudicus* is familiar to every person who has directed any attention to the subject of fungoid growth, and the genus *Trichia* forms no exception to this rule. Now if spiral fibres exist, they must be admitted to be formed in the same manner as all other spiral fibres are supposed to be produced, viz., by gradual and successive deposits of thickening matter upon the internal wall of the cells; and if this be so, it is difficult to see how, in the short period allotted for the completion of the growth of the fungus, the fibres can find time to perfect themselves.

A further objection arises from the impossibility of detaching the apparent spiral from the wall of the cell; I assume that this has never been effected, because if it had been the question would be concluded. I have tried the action of many reagents upon these threads, but have never succeeded in obtaining a free fibre. Now if the elaters of a *Jungermannia*, with which more than with anything else the *Trichia*-threads have been compared, be treated with sulphuric acid,

the cell-membrane is dissolved and the spiral fibre left free; I have tried the effect with the *Trichia*-threads, and have found them either to *resist the action of the acid altogether*, or, if the acid operated, that the threads became uniformly charred, but presenting nothing to lead to the conclusion of the existence of a spiral fibre. Moreover, if iodine and sulphuric acid be employed, the effect produced upon the cell-wall and upon the supposed spiral fibre is the same.

Another objection to the fibre theory appears to me to arise from the unevenness or rather waviness of outline which exists in almost all the threads which I have examined, and which is not usual in spiral vessels in general; and also from the fact that the end of the supposed fibre is never to be seen protruding from the cell, which might be expected when the threads are ruptured as they frequently are.

The theory of Schleiden and Schacht that the spiral appearance is caused by the twisting of flat band-like cells is very difficult to be maintained, and I cannot help thinking that they have formed their opinions from an examination only of such simple threads as are represented in figs. 1 and 4. It might be possible for the spiral appearance in such cells to be produced by a twist, but I cannot conceive how the "*Drehung um sich selbst*," as Schacht expresses it, of the cells can be called in aid to explain the spiral appearance in such a thread as that of *T. serpula*, shown in fig. 8; the thing seems to be mechanically impossible.

If the above theories be incorrect, it may be asked, in what other manner is it possible to account for the spiral appearance? Now it seems to me that it may be accounted for by supposing the existence of an accurate elevation in the wall of the cell, following a spiral direction from one end of the threads to the other This supposition would, I think, accord well with the optical appearances, and it would account exactly for the undulations of outline to which I have before referred. I have in my possession a thread of *Trichia chrysosperma*, in which the spiral appearance is so manifestly caused by an elevation of this nature – in which it is so clear that no internal spiral fibre exists—that I do not think there could be a doubt in the mind of any person carefully examining it with a power of 500 diameters, that the cause of the spiral appearance is *not* a spiral fibre. I have also a species of *Arcyria*, in which the threads are (as in the other *Arcyria*) echinilate or denticulate, and the teeth appear to take a spiral direction round the threads; these teeth are mostly at a short distance apart; but at a spot where the teeth are so close as to have become confluent, the appearance produced is almost precisely the

same as the appearance in the *Trichia*-threads. I have seen on one occasion the membrane of a thread of *T. pyriformis* unrolled spirally in the manner represented in fig. 10, Plate II.; this circumstance is somewhat curious, as *membrane* does not ordinarily unrol in that manner, although it has been observed by Professor Quekett to take place in the hairs of the fruit of *Cycas revoluta*.* I do not know that this fact has any very strong bearing upon the question of structures; but if, as would seem to be the case from its greater transparency, the elevated position of the cell-wall is thinner than the rest, it is easy to imagine that a rupture of the wall would be likely to take a spiral direction.

The following is a list of the *Trichia* hitherto recorded as British, viz., *Trichia pyriformis*, *serotina*, *fallax*, *clavata*, *turbinata*, *chrysosperma*, *varia*, *Serpula*, *Neesiana*,† and *Ayresii*; and to these must be added *Trichia nigripes*, which I met with last autumn in the neighbourhood of Eltham in Kent.

With regard to the preparation of the *Trichia*-threads for the microscope, there are many methods which may be used. Owing perhaps to the dense crowding of the hairs, the getting rid of air-bubbles is the principal difficulty. Alcohol is the *easiest* medium to employ, and I have reason to think that the colour of the threads is not affected by it, which is the only thing which might be feared. Deane's gelatine is a very good preservative, and may be used without difficulty if the threads are previously left to soak for some hours in chloride of calcium; and castor oil answers admirably well, although when this is used there is sometimes a little difficulty in fixing the thin glass cover. In conclusion, I would venture to express a hope that some of the readers of the Microscopical Journal may be induced to direct their attention to the investigation of these disputed threads; irrespective of the interesting question of structure, the beauty of the objects will fully compensate them for the trouble of examination.

Observations on Aphanizomenon Flos-aquæ, *and a species of* Peridinea. By G. J. Allman, M.D., Professor of Botany in the University of Dublin.

The substance of the following communication has already appeared in the Proceedings of the Royal Irish Academy;

* See Lectures on Histology, p. 100.

† Fries has expressed an opinion that *Trichia Neesiana* is identical with *T. rubiformis*; Bonorden, however, asserts, that in *T. rubiformis* there is no spiral appearance. If this be so, they cannot be identical; for *T. Neesiana* shows the spiral marking more beautifully than any which I have examined.

but having made some additional observations, I have thought them of sufficient interest for publication in the Microscopical Journal. The first part of the paper consists of the results of some observations made on *Aphanizomenon Flos-aquæ*. This minute alga has appeared in great abundance in the large pond of the Zoological Gardens, Dublin. The best account we possess of the plant is in an excellent paper on the Nostochineæ, by Mr. Ralfs;* but as the specimens from which Mr. Ralfs's description was drawn up were not in a recent state, some important points of structure have necessarily escaped him.

A. Flos-aquæ shows itself in the form of little fusiform fasciculi, of a pea-green colour (Plate III., fig. 1), which are most frequently seen united to one another in larger bundles, fig. 2. This union of the primary fasciculi into secondary ones is not permanent, and under certain circumstances very imperfectly understood; but, in some cases, depending perhaps on meteorological conditions, the secondary fasciculi become broken up into primary ones, or, at least, into less complicated bundles, and the plant, which had previously lain upon the surface of the pond in an extensive stratum, becomes nearly uniformly diffused through the water. A return of the former conditions will again cause the union of the simpler fasciculi into more complex ones, and the reaccumulation of the plant in masses on the surface.

The primary fasciculi are composed of straight filaments, which are about 1-3000th of an inch in diameter, and possess the three kinds of cells characteristic of the Nostochineæ, namely, the *ordinary cells*, the *heterocysts*, and the *sporangia*.

The ordinary (figs. 4, 5 *a*, *a*) cells vary much in length in different filaments, and sometimes even in the same filament, and not unfrequently they present evident transverse striæ, which doubtless indicate the commencement of division; the endochrome is in the form of several oval or irregular granules in each cell. Under the action of iodine the contents of the cells assume a dark-brown colour, and separating from the walls contract towards the centre of the cell, where they appear bounded by a very definite outline (primordial utricle), fig. 6 *a*. The entire filament appeared in some cases to be surrounded by an indistinct gelatinous (?) sheath.

When the *Aphanizomenon* first showed itself in the pond, the heterocysts were abundant; but no sporangia could be detected. The heterocysts fig. 5 *b*, are in the form of short cylinders with rounded extremities, and with bluish-green

* On the *Nostochineæ*. By John Ralfs, M.R.C.S., Ann. and Mag. of Nat. Hist., May, 1850.

contents, which scarcely ever present any trace of granular structure. Under the action of iodine the following structures, fig. 6 *b*, may be seen in the heterocyst:—1. The endochrome contracted towards the centre of the cell, and presenting a well-defined boundary. 2. External to this a delicate cell-wall separated from the contracted endochrome by a transparent interval, and frequently presenting in its interior, at each extremity, a minute spherical body, with considerable refractive powers. 3. An external very delicate, but well-defined transparent investment.

At first no other kind of cell beyond those now described could be detected in the filaments, but in specimens gathered somewhat later many filaments presented in some part of their course a long cylindrical and slightly-dilated cell, fig. 4 *b b*, generally about two or three times the length of the heterocysts; occasionally a single filament presented two such cells. They correspond to the cells named sporangia in the other Nostochineæ; their contents are always minutely granular, and under the action of iodine, fig. 7, separate from the walls of the cell and contract towards the centre, where they present a very definite boundary, in which a double outline can sometimes be distinctly seen; while, external to this, and separated from it by a clear space, a colourless investing membrane has become very obvious; but the second investment, so evident in the heterocysts, could not here be satisfactorily demonstrated: the little spherical body visible at each extremity of the cell of the heterocyst could not be seen in the sporangium. Filaments bearing sporangia were accompanied by those bearing heterocysts, but whether the two kinds of cells ever coexisted in the same filament was not manifest.

That the sporangia are not simply enlarged cells, but the result of the union of several ordinary cells, is highly probable. The author has succeeded in observing what appears to be intermediate stages of formation, in which the endochrome of a group of ordinary cells had already begun to assume the minutely-granular condition of that of the sporangium, the septa being, at the same time, evidently in process of disappearing, fig. 8.

When the living plant is collected and placed in a jar of water, the fasciculi will frequently be seen after some hours to have broken up into their component filaments, which will then rearrange themselves in elegant wavy curves parallel to one another, and forming a nearly uninterrupted stratum on the surface of the water, fig. 3.

Aphanizomenon Flos-aquæ, after the death of the plant, is eminently sensitive to the action of light. Specimens dried on

paper in the shade are of a dull yellowish-green; but if these be now exposed to the direct rays of the sun, for about ten minutes, they will be found to have assumed a bright bluish-green, which they do not again lose.

During decomposition in water a fluid is produced, which is of a claret-red under reflected light, but of a fine grass-green when viewed by transmitted light.

The next subject to which I would draw attention is a species of *Peridinea*, which had just shown itself in such inconceivable multitudes as to give rise to a peculiar coloration of some of the ponds in the Phœnix Park. During the last three weeks a spectator on the banks of the large ponds * in the Park must have been struck by a brown colour assumed by the water. This colour was sometimes uniformly diffused through the water; at other times it appeared as dense clouds, varying from a few square yards to upwards of 100 in extent.

A microscopic examination of the water proved the brown colour to be entirely due to the presence of a minute organism, which, though it does not exactly agree with any published generic description, I have thought it better, by slightly modifying the genus *Peridinea*, as characterised by Ehrenberg, to place it in that genus rather than construct for it a new one.

It varies from the 1-1000th to the 1-500th of an inch in diameter, and approaches in form to a sphere (Plate III., figs. 9, 10), divided by a deep annular furrow into two hemispheres, on one of which is situated another furrow, springing vertically from the annular furrow, and terminating at the pole. The organism under consideration may be regarded as essentially a solitary cell; it encloses reddish-brown granular contents, and a large, well-defined central nucleus. In the midst of the contents are numerous clear spaces, of various sizes, which, however, appear to be oil-drops rather than true vacuolæ.

In most instances a deeper-coloured ocelliform spot was evident near the polar extremity of the vertical furrow.

It is eminently locomotive, swimming with great activity by the aid of a flagelliform appendage, which springs from the vertical furrow near the point of junction with the other, and of very minute vibratile cilia, which seem distributed over the surface, and not confined to the furrows, as maintained by Ehrenberg, in the species of *Peridineæ* described by him.

Before death, and also when only passing from a motile to

* The two large ponds communicate with one another, and together occupy a space of about 14 acres. The observations were made in June, 1854.

a quiescent state, most likely preparatory to undergoing some important developmental change, the contents contract towards the centre, and then an external transparent and perfectly-colourless vesicle becomes visible while the flagellum and cilia disappear, fig. 11. The contracted contents present a very definite and generally spherical boundary, and are evidently included in a distinct cell: the resemblance of this internal cell to the primordial utricle, and that of the external investing vesicle to the cellulose wall of the vegetable cell, are too obvious to be overlooked, though the iodine and sulphuric acid test failed in indicating the presence of cellulose. The external investing vesicle is non-contractile; under pressure it is easily ruptured, and the minutely-granular contents, mixed with large oil-drops (?), escape upon the stage of the microscope, fig. 12. The nucleus is then easily isolated; it is of an irregular, oval form, quite colourless, and marked on its surface with curved striæ, fig. 13.

Individuals were frequently seen undergoing spontaneous division, which takes place parallel to the annular furrow, and in the unfurrowed hemisphere, fig. 14. This process appears to be invariably preceded by a division of the nucleus, and the author had succeeded in isolating nuclei, presenting almost every stage of transverse fission, figs. 16, 17.

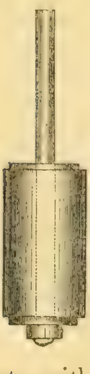
Believing the species now described to be new, I have named it *P. uberrima.*

Since communicating the above facts to the Academy, the coloration of the ponds has much increased in intensity. On the 9th of July I again visited them. The colour in some parts was then of so deep a brown, that a white disc, half an inch in diameter, became invisible when plunged to a depth of from 3 to 6 inches, while a copious exit stream, which constantly flowed away from one of the ponds, presented the same deep-brown tint. In many places the *Peridinea* had descended from the surface, and were found to be congregated in immense masses towards the bottom, where they appeared to be quite healthy, though presenting the condition described above as characterising the quiescent state of the animalcule. It is highly probable that this contracted condition of *Peridinea*—a condition, however, which must not be confounded with the encysting process observed in many infusoria—is connected with reproduction. A field of much interest is here open for investigation, but I was unfortunately at this point obliged to discontinue my observations.

On the Deep Diatomaceous Deposits *of the* Mud *of* Milford Haven *and other* Localities. By Fitzmaurice Okeden, C.E.

At the time that Mr. Roper's interesting paper on the Thames mud appeared, I was myself engaged in examining the mud of Neyland, which is a creek of Milford Haven and the terminus of the South Wales Railway. At this time, also, we were engaged in making borings for engineering purposes to ascertain the depth of the mud in this creek, and in some places we found that it exceeded 40 and even 50 feet.

It struck me that it would be interesting to ascertain whether the mud at these great depths was as rich in diatomaceous remains as the surface had proved to be in the living specimens. I accordingly had constructed a simple, but I think effective, apparatus, for the purpose of obtaining the genuine mud from any depth that might be reached, and of insuring that it should be unmixed or uncontaminated with any other deposit. I will, therefore, before laying the results before the reader, describe the apparatus made use of. I must premise that the usual "boring" apparatus employed for engineering purposes consists essentially of any number of iron rods, which screw one into the other; to one of these is screwed an auger or a chisel-point, as the case may require. This is inserted into the ground to be tested, and worked round by manual force and downward pressure, length after length of rod being added as the ground is penetrated. In addition, then, to this apparatus, I obtained, first, several lengths of wrought-iron gas-pipe, about an inch in diameter, and each screwing into the other, and also a similar number of iron rods, each a few inches longer than the lengths of gas-piping, and each also screwing into the other; to the end of one of these lengths of rod is attached a cork of the *exact* diameter of the gas-pipe, or a trifle larger. This cork is fixed by a washer and nut, as shown in the sketch. The gas-piping should be in lengths of about 8 feet each, as this is the most convenient in work: *one* of these lengths should also be again divided into two parts, which must, however, screw and unscrew; and this length is to be the one *first* put into the ground or mud, for reasons which I will presently explain.



The mode of proceeding is as follows: First, a hole is bored to the required depth—say 20 feet—with the usual boring apparatus; this done, the appa-

ratus is drawn out, the jointed length of gas-pipe is now introduced, the end of it with the rod to which the cork is attached having been previously stopped, the rod passing up the centre of the gas-pipe; this is let down the hole, another length of pipe being attached, and another length of rod, and so on, length after length of pipe and rod, until the bottom of the hole is reached. We shall thus have a continuous length of gas-piping, which will be penetrated by a continuous length of iron rod attached to the cork at the end of the pipe. It is obvious that this cork will entirely prevent any foreign matter from entering the gas-pipe. Having thus reached the bottom of the hole, now pull up the cork into the gas-pipe about 4 feet, by means of the rod attached to it, and then *press* the whole apparatus into the soft mud. The pressure will now drive the mud up into the pipe as far as the cork is drawn up; now remove the whole apparatus, and by means of the rod push the cork back again to the end of the last length of pipe, when the charge of mud will be driven out in the form of a sausage, and, by rejecting the two ends of it, and taking only the middle piece, we may be perfectly sure that the mud at that depth, and that only, has been obtained.

Having secured the prize, the short length of piping which contained it is now to be unscrewed, and carefully washed with a common gun-cleaning rod and some tow, when it is ready for another experiment.

With this apparatus, then, I have penetrated Neyland mud in various places to depths of 20, 30, and 40 feet; and the results have been so interesting, and the deposits have proved so rich in Diatomaceous remains, that I have been tempted to put some of the results upon paper.

The first trial I made was at a depth of 20 feet; and a careful examination of this deposit, when well cleaned, and the coarse sand thoroughly separated, gives us a list of the following forms:—

Fresh-water Species.

Epithemia alpestris.	Pinnularia viridis.
Campylodiscus costatus.	,, radiosa.
Surirella biseriata.	,, major.
Navicula ovalis.	Gomphonema geminatum, *g*.

Marine, or Brackish.

Cocconeis scutellum, (*a*).	Coscinodiscus eccentricus.
,, ,, *a'*.	,, Ocellus iridis.
,, ,, *β*.	Actinocyclus undulatus.
,, Grevillii.	,, sedenarius.
Coscinodiscus radiatus.	Triceratium favus.

Triceratium comptum ?
,, alternans.
,, armatum, n. sp.
Eupodiscus sculptus.
Campylodiscus Hodgsonii.
,, cribrosus.
,, parvulus.
Surirella ovata.
,, fastuosa.
,, lata.
Tryblionella marginata.
,, punctata.
,, acuminata.
,, scutellum.
Nitzschia sigma.
Amphiprora constricta.
Navicula Jennerii.
,, didyma (*a*).
,, ,, (*a'*).
,, ,, (*a**).
,, punctulata.
,, convexa.
,, elliptica.
,, palpebralis.
Navicula liber.
Pinnularia cyprinus.
,, distans.
,, peregrina.
Stauroneis pulchella.
Pleurosigma formosum.
,, angulatum.
,, Balticum.
,, tenuissimum.
Synedra superba.
Doryphora amphiceros.
Achnanthes brevipes.
Rhabdonema minutum.
,, arcuatum.
Grammatophora serpentum.
Amphitetras antediluviana.
Isthmia enervis.
Biddulphia aurita.
,, rhombus.
,, quinque-oculus, Kutz.
Podosira maculata.
Melosira sulcata.
,, Borreri.
Dictyocha speculum.

I have also two fine specimens of what I thought to be a new *Navicula;* but on referring them to Mr. Smith, he informed me that it had been already observed by Mr. Hennedy, and it has been named *N. Hennedii* by Mr. Smith. It was in this deposit that I found the first specimen of the *Triceratium* which has been described and named by Mr. Roper as *T. armatum.*

The prevailing form, however, is the *Navicula Jennerii*, which is extremely abundant. The specimens of *Coscinodiscus* are also magnificent and abundant.

Of the *Triceratia*, *T. favus*, and *T. comptum* (?) are very abundant. *T. alternans* occurs but sparingly.

The beautiful valve of *Actinocyclus sedenarius*, described by Mr. Roper in his paper on the Thames mud, occurs but sparingly; all the other forms in the foregoing list are tolerably abundant, and occur also in the 30 and 40 feet deposits.

T. favus occurs also pretty frequently at both these depths, while in the 30-feet deposit I found a most curious and interesting form, of which I have sent specimens. Mr. Smith informs me it is the *Cerataulus turgidus* of Ehrenberg, and will be the *Biddulphia turgida* of Mr. Smith's second volume. I am not aware that it has been hitherto figured or described by any one as a British species.

But it is not always necessary to resort to the boring apparatus to obtain material for investigating these deep

deposits. Wherever excavations for building or other purposes are going on near the banks of a tidal river, there will be found an ample field for the industrious observer.

At Swansea, for instance, where some docks are now being constructed, I have obtained some rich samples of Diatomaceous clays.

The strata through which these excavations are being made occur in the following order:—

		Feet.
	Gravel and sand . .	10
D	Clay	5
	Peat	1
	Sandy clay . . .	4
D	Clay	2
	Peat	1
	Clay	2
	Total . .	25

The lowest bed of this clay, at 25 feet depth, is literally "swarming" with *Epithemia musculus* and *Surirella striatula:* other marine forms are abundant; while the fact of *two* beds of peat lying above it shows its extreme antiquity. The other two beds of clay above it, marked D D, are also rich in Diatomaceous remains. I have not yet had time to examine these deposits thoroughly, so as to make lists of the forms occurring in them; but a comparative examination of the three beds would be highly interesting, and I hope to be able to prepare one for the next number of this Journal.

Again, from a brick-yard near Carmarthen, which is now upwards of a hundred yards from the present banks of the river (the Towy), and at a depth of about five feet below the surface of the ground, I have obtained a sample of the old tidal deposit which now forms the brick-earth, and which is full of the most magnificent specimens of *Triceratium favus* and *Coscinodiscus* that I have ever seen; while the beautiful *Actinocyclus sedenarius*, with its sixteen septa, is of common occurrence.

From the foundations of a bridge we are now building over the Cleddan near this town (Haverfordwest), I have also obtained a rich sample of clay at a depth of about 10 feet, and at about 20 feet distance from the present bank of the river. In this sample the fresh-water forms occur more frequently than in the other deposits. This might be expected, as the tidal influence does not extend very far above this point.

I could enumerate many other instances which have come under my notice, but it would be only a repetition of the

above facts: indeed, I have rarely tried a sample from any of these clays, either near a fresh or brackish stream, in which a careful washing would not eliminate abundance of Diatomaceous remains. Of course, some will be richer than others, but I have found them in all. Let it not be thought that too enthusiastic a view has been taken of the subject. I have sent a set of slides illustrative of all the above-mentioned deposits to the Editors of this Journal, and I think they will bear me out in the assertion that neither their richness nor their interest has been overstated.*

From these facts it appears that not the surface merely, but the whole mass of these tidal deposits, is penetrated by these minute and wondrous organisms; while from the fact of their being found at Neyland at a depth of 40 feet below the present surface, and close upon the rock which forms the original bed of this estuary, the mind is irresistibly led to the conclusion that they have existed there from the time when the waters first rolled over the spot, when silence and solitude reigned supreme where now resounds the "busy hum" of the hundreds who are employed in bringing one of the great arteries of commerce and civilization to its ocean home.

In making out the list of the forms in the Neyland deposits, I have carefully abstained from inserting the names of any but those which I could identify with certainty, either from Mr. Smith's work or from information furnished to me by Mr. Roper, to whose kind assistance I am deeply indebted during the time I have been studying the subject. Being but a beginner in the study, I thought this the best plan to adopt; but I am sure, from what I have observed, that were these deposits well examined by other and more experienced investigators than myself, the list might be far more extended, and many new forms brought to light. Still, if I shall have been the means of drawing attention to the subject of these deep deposits, or of extending in any way, however small, the boundaries of this interesting field of research, I shall feel amply recompensed for any trouble I have taken in this matter.

On a Post-Tertiary Lacustrine Sand, *containing* Diatomaceous Exuviæ, *from Glenshira, near Inverary.* By William Gregory, M.D., F.R.S.E., Professor of Chemistry.

This remarkable deposit was sent to me in February last by the Duke of Argyll, who had found it in the valley of Glen-

* The slides sent us by Mr. Okeden are uncommonly rich in the various forms of *Diatomaceæ*.—Eds.

shira, the waters of which flow into Loch Fine, well known as a sea-loch, at its upper part. The sand occurs above a mile from the mouth of the valley, lying under a considerable depth of good alluvial soil. It is nearly black, with shining particles of mica, and very dense. It consists chiefly of the detritus of the surrounding mountains, formed of micaceous schist, and contains therefore much quartz and mica. There is also a considerable proportion of an iron ore, and of a dark matter of vegetable origin, and apparently somewhat of a peaty character. To the last-named ingredients the dark colour of the sand is due.

On placing a little of it under the microscope, I noticed one or two Diatomaceous forms, such as a *Navicula didyma*, a *Cocconeis scutellum*, and a *Synedra radians*. But the proportion of these was so small that without some purification nothing could be done. After various trials, I found the following plan to yield tolerably satisfactory results.

The mass was first warmed, and when the violence of the action had passed, boiled, with the most concentrated nitromuriatic acid. This not only dissolved the iron ore, but completely removed the dark organic matter, and left a sand of a pale-yellowish colour, in which the Diatomes were more easily seen.

The next step was to remove, by subsidence in water and decantation, the greater part of the quartz and all but the finest and lightest scales of mica, which, having much the same density as the shells, could not be got rid of. Any attempt to push the process farther caused a loss of shells. The residue thus obtained was now found to be rich in Diatomes; and when mounted in Canada balsam, the mica became so transparent as not materially to interfere with the examination of the shells. The entire residue did not exceed 1-20th of the original sand, and the Diatomes formed only from 1-5th to 1-3rd of the residue, so that they could not have amounted to much more than 1 or 2 per cent. of the mass.

It will be seen from this, that the Glenshira deposit is of an entirely different character from those earths in which Diatomes have usually been found in the fossil state, such as the Raasay or Mull deposits, which consist entirely of Diatomaceous shells. On the other hand, it presents all the characters of a lacustrine or estuarial deposit or mud, such as the Thames mud, or similar deposits now forming in estuaries or lakes. Of course the predominant mineral ingredients are such as are yielded by the adjacent rocks, and the Diatomes have merely been deposited in small proportion along with these. We shall see that there is a very remarkable analogy,

as far as concerns the Diatomes present, between this sand and the Thames mud recently described by Mr. Roper in the second volume of the "Journal."

The first glance at the Glenshira sand under the microscope leads to the observation, that, like the Thames mud, it contains both marine and fresh-water forms. In this respect it resembles the deposit or mud of all estuaries. From its position, however, there is every reason to conclude that it was formed in its present locality, when that part of the valley was occupied by a fresh-water lake, which is now confined to the lower part of the valley, but has evidently extended much higher in former periods. The question of course naturally occurs, whence came the abundant marine forms? But this is easily explained, if we attend to what is going on in the present small fresh-water lake. The level of this lake is precisely that of half tide, so that at high water the sea flows into it, while at ebb tide the water of the lake runs into the sea.

This remarkable state of matters produces a mixture, in the lake, of fresh-water and marine forms, both animal and vegetable. The Duke of Argyll mentions, that nets, thrown for salmon in the lake, have been drawn up full of herring; that other marine animals occur in it, and that marine algæ are also found, dwarfed by the influence of the fresh water. Having been supplied with some of the deposit or mud now forming in the lake, I examined it, and found it very closely to resemble the sand from the higher level, save that the proportion of organic matter was considerably greater. But, like the older sand, it contains both marine and fresh-water Diatomes, and these belong in many instances to the same species. I have noticed some difference in the relative proportions of species, and I shall take an opportunity of carefully studying the recent deposit or mud of the lake; but in the mean time I can state, that in all essential characters the recent deposit agrees with the fossil one.

From these facts it may be inferred that the lacustrine sand of Glenshira, which I refer to the post-tertiary period, on the authority of the Duke of Argyll and of Mr. Smith of Jordanhill, both of whom are familiar with the localities, was formed in the lake when that lake occupied the part of the valley where the sand occurs, and that the relative levels of lake and sea were then the same as now. This seems to be the simplest mode of accounting for the abundance both of fresh-water and of marine forms. Had the sand been deposited in sea water, it could not have been, as it is, extremely rich in fresh-water species, and there is no reason to suppose

it to have been formed in an estuary, like the Thames mud, when we see a similar deposit in course of formation at the present hour in the fresh-water lake, not much more than a mile from the spot.

But if this be admitted, then it must also follow that, since the relative levels of sea and lake were the same then as now, and since the sand occurs at a considerably higher level than that of the present lake,—it must, I think, follow, that the sea has fallen, or the land has risen, since the period when the sand was deposited. This is a conclusion at which geologists have arrived in many instances, from other phenomena, such as raised beaches, as, for example, in the Clyde, with which Loch Fine communicates. It is interesting to find the study of the Diatomaceous forms, occurring so scantily in this deposit, assisting to throw light on one of the *quæstiones vexatæ* of geology.

I have said that the Diatomes are but scantily diffused in the Glenshira sand; and this is true, since they do not much exceed 1 per cent. of the mass. But when we examine the purified or cleaned residue, in which they are, as it were, concentrated, we are struck at once with the very large number of species present.

In this respect the Glenshira sand far surpasses every deposit hitherto described, even that of Mull, in which I have found 150 species, and the Thames mud, in which Mr. Roper detected 104 species.

In the Mull deposit all the species, with a very few exceptions, and these so rare as to be evidently accidental, derived from the proximity of the sea, and possibly carried by the winds, belong to fresh water. But in the Thames mud and in the Glenshira sand, as already stated, both classes of forms occur abundantly. It is this which accounts for the large number of species. Up to the present time I have recognised in the latter not less than 240 species, and I am quite satisfied that a good many remain to be identified. Judging from what has been done already, I cannot doubt that the number of species will, before long, amount to at least 250.

In consequence of the circumstances under which it has been formed, this deposit does not contain any one or more greatly predominant form, as is generally observed to be the case in deposits formed where the Diatomes grew and died. As they have all been transported by water, they constitute, when the quartz, mica, and other matters which separate them are removed, a mixture of a very remarkable kind, in which a large number of forms are tolerably abundant, and a still larger number are pretty frequent, while none are so pre-

dominant as we find them in recent gatherings, and a good many are so scarce, that we have often to search long before finding additional specimens, although with patience we generally succeed in doing so.

The peculiar constitution we have described renders a complete study of this deposit a work of much time and labour. I soon found that it was only by pursuing the minute and systematic mode of search which I have described in my account of the Mull deposit, that I could hope to determine the species present in this one. I have found it, however, advantageous, in consequence of the large number and relative scarcity of new forms in the Glenshira sand, to adopt the plan of marking any striking forms, or such as require to be examined, or are to be figured, when first observed. I find the best way of marking is, after fixing on the form, to put on the 2-3rd objective, and under that power to place one spot of ink *just above*, but not *on*, the form. This is much more rapidly and easily done than drawing a circle round it, and it interferes much less with the remaining forms. A note is kept of all the spots made on each slide, arranging them in a certain order, according as they follow in the regular course of sweeping the slides. By this means any marked form is instantly recovered; and I have been able to place in the hands of Mr. West, in the course of one forenoon, a number of new and striking forms so great, that without some such method I could not have pointed them out, from their comparative scarcity, under a much longer time.

It may be here mentioned, that, in studying a mixture like the present, no examination, short of a thorough and minute search, would suffice. Without this we should infallibly miss a large proportion of the most interesting forms. To give some idea of the necessity of this, I may state that I have found it necessary to explore, minutely and repeatedly, 60 well-filled slides of this deposit, and that I have not yet exhausted it, as even now I hardly ever search one of these slides without observing something new or interesting previously overlooked.

This is no doubt very laborious, but without labour nothing can be well done, and in the present case the results have been highly satisfactory. I have recognised upwards of 200 known species, while a number remain that for the present I cannot exactly name, for want of good figures; and besides this, I have distinguished about 25, probably more, new and undescribed forms, most of which are very interesting. Such is a general account of the results obtained; and after these preliminary remarks I shall now proceed to the details. I shall

first give the list of known species, under the two heads of marine and fresh-water forms, as Mr. Roper has done in the case of the Thames mud; and I shall then briefly describe the new species, which will also be figured. But as circumstances have rendered it impossible for me to have more than one plate in the present number of the 'Journal,' I am compelled to reserve one-half of the figures till the next number.

It is proper to explain that I shall have to mention several new forms, as occurring in this deposit, which I do not figure, although no figures have as yet appeared of them. The reason is, that these forms have been recently observed by others, prior to me, and it is to be presumed that the first observers will take an early opportunity of describing and figuring them. I propose to figure all such forms as are now, for the first time, distinguished by myself, and also some striking varieties of known species, in which the Glenshira deposit is uncommonly rich. Without further preamble, let us now proceed to the list of known forms.

I. *Marine Species*,

including such as occur in both sea water and brackish water, as well as those which seem to belong to brackish water more especially:—

1. Epithemia Musculus.
2. Amphora affinis.
3. ,, tenera.
4. ,, costata.
5. Cocconeis Scutellum.
6. ,, Grevillii.
7. Coscinodiscus radiatus.
8. ,, excentricus.
9. Eupodiscus crassus.
10. ,, Ralfsii.
11. Campylodiscus parvulus.
12. Surirella fastuosa.
13. ,, constricta.
14. Tryblionella punctata.
15. ,, acuminata.
16. Nitzschia Sigma.
17. ,, angularis.
18. ,, birostrata.
19. Amphiprora alata.
20. ,, constricta.
21. ,, vitrea.
22. Amphipleura sigmoidea.
23. Navicula Liber.
24. ,, Smithii.*
25. ,, Jenneri.
26. ,, convexa.
27. ,, elegans.
28. ,, palpebralis.
29. ,, punctulata.
30. ,, pusilla.
31. ,, Didyma.
32. ,, nitida.†
33. ,, granulata, Bréb.‡
34. Pinnularia directa.
35. ,, Cyprinus.
36. ,, peregrina.
37. Stauroneis pulchella.
38. ,, salina.
39. Pleurosigma formosum.
40. ,, angulatum.
41. ,, Balticum.
42. ,, strigosum.

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* *N. elliptica*, W. Sm. M. de Brébisson has given this name, on account of the term '*elliptica*' having been long applied to another species by continental writers.

† This is a beautiful new species, to be figured in vol. ii. of Mr. Smith's 'Synopsis.'

‡ Also a very fine new form. Prof. Arnott finds it in the Clyde.

43. Pleurosigma rigidum.
44. Synedra superba.
45. „ acicularis.
46. Gomphonema marinum.
47. Achnanthes longipes.
48. „ brevipes.
49. „ subsessilis.
50. Rhabdonema arcuatum.
51. „ minutum.
52. Zygoceros Surirella.*
53. Grammatophora marina.
54. „ serpentina.
55. Amphitetras antediluvianum.
56. Biddulphia aurita.
57. Melosira Borreri.
58. „ sulcata.
59. Orthosira nummuloides.
60. Podosira hormoides.
61. „ maculata.
62. Bacillaria paradoxa.
63. Dictyocha Speculum.
64. „ gracilis.
65. „ Fibula.
66. „ trifenestra.
67. Schizonema Crux.

Total, 67 marine species.

II. *Fresh-water Species*,

including such as occur in both fresh and brackish water:—

1. Epithemia Hyndmanni.
2. „ turgida.
3. „ gibba.
4. „ Argus.
5. „ Zebra.
6. „ Westermanni.
7. „ rupestris.
8. „ Sorex.
9. „ proboscidea.
10. „ alpestris.
11. „ longicornis.
12. „ constricta.
13. Cymbella Ehrenbergii.
14. „ Helvetica.
15. „ Scotica.
16. „ maculata.
17. „ affinis.
18. „ cuspidata.
19. Eunotia Arcus.
20. „ monodon.
21. „ diodon.
22. „ triodon.
23. „ tetraodon.
24. „ bigibba.
25. „ Camelus.
26. „ incisa.
27. „ depressa.
28. Amphora ovalis.
29. „ minutissima.
30. Cocconeis Pediculus.
31. „ Placentula.
32. „ Thwaitesii.
33. Coscinodiscus minor.
34. Cyclotella operculata.
35. „ rotula.
36. Campylodiscus costatus.
37. „ bicostatus.†
38. Surirella minuta.
39. „ pinnata.
40. „ ovata.
41. „ Brightwellii.
42. „ Crumena.‡
43. Tryblionella marginata.
44. Cymatopleura Solea.
45. Nitzschia sigmoidea.
46. „ minutissima.
47. „ acicularis.
48. „ linearis.
49. „ amphioxys.
50. „ vivax.
51. Amphipleura pellucida.
52. Navicula rhomboides.
53. „ ovalis.
54. „ minutula.
55. „ firma.
56. „ affinis.
57. „ amphisbæna.
58. „ crassinervia.
59. „ lanceolata.
60. „ gibberula.
61. „ angustata.
62. „ Semen.
63. Pinnularia major.
64. „ viridis.
65. „ lata.
66. „ acuta.

* Figured by Mr. Roper in No. VII. of the 'Journal.'
† Figured by Mr. Roper, *loc. cit.*
‡ A new fresh-water species, first distinguished, I believe, by Professor Walker Arnott.

67. Pinnularia radiosa.
68. „ oblonga.
69. „ divergens.
70. „ gibba.
71. „ gracilis.
72. „ viridula.
73. „ mesolepta.
74. „ stauroneiformis.
75. „ latestriata.*
76. „ undulata.*
77. „ tenuis.*
78. „ parva.*
79. „ exigua.*
80. Stauroneis Phœnicenteron.
81. „ gracilis.
82. „ anceps.
83. „ dilatata.
84. „ punctata.
85. „ rectangularis.*
86. Pleurosigma attenuatum.
87. Synedra Ulna.
88. „ radians.
89. „ pulchella.
90. „ obtusa.
91. „ biceps.
92. „ lunaris.
93. „ acicularis.
94. Cocconema lanceolatum.
95. „ Cistula.
96. „ cymbiforme.
97. „ gibbum.
98. Gomphonema geminatum.
99. „ acuminatum.
100. „ coronatum.
101. „ curvatum.
102. „ constrictum.
103. „ capitatum.
104. „ tenellum.
105. Gomphonema dichotomum.
106. „ Fusticulus.†
107. „ insigne.‡
108. Meridion circulare.
109. „ constrictum.
110. Achnanthes exilis
111. Achnanthidium lanceolatum.
112. „ coarctatum, Bréb.
113 Himantidium majus.
114. „ Arcus.
115. „ pectinale.
116. „ gracile.
117. „ bidens.
118. Fragillaria capucina.
119. „ virescens.
120. Odontidium mesodon.
121. „ mutabile.
122. „ Tabellaria.
123. „ Harrisoni.§
124. Denticula tenuis.
125. „ sinuata.
126. Tabellaria fenestrata.
127. „ flocculosa.
128. „ ventricosa.
129. Diatoma vulgare.
130. „ elongatum.
131. Melosira varians.
132. Orthosira arenaria.
133. „ nivalis.
134. Mastogloia elliptica.
135. „ Dansei.
136. Colletonema neglectum.
137. „ vulgare.
138. „ subflexile.
139. Encyonema prostratum.
140. „ cæspitosum.

Total, 140 fresh-water species, which, added to 67 marine forms, gives a grand total of 207 species, known as British.

To these must be added a few which have now, for the first time, occurred in this country, though known on the Continent. Such are—

208. Navicula nodosa,‖ Kützing.
209. Pinnularia pachycephala,¶ Rabenhorst.
210. „ (Navicula) Gastrum.** Ehr.

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* These six species are figured in my account of the Mull deposit.

† This species has lately been distinguished by Mr. Smith.

‡ A new species, which I shall describe and figure in the next number of the 'Journal,' along with several other recent forms, which I have observed during the past year.

§ A beautiful form, lately detected by Mr. Harrison.

‖ To be figured in the next number of the 'Journal.'

¶ Occurs also in the Mull deposit, and will be figured in next number.

** This form is figured in the present paper. See fig. 20.

We have thus in the Glenshira sand 210 known and described species, with the exception of one or two recently observed and likely to be soon figured. But I feel quite assured that there are a good many more, belonging to this category, which I am unable clearly to identify, from the want of good figures, especially in those genera to be figured in vol. ii. of Mr. Smith's Synopsis. In particular, there appear to be several discoid forms of the genera *Melosira* and *Orthosira*, &c., which will be found to be of known species.

Let us now turn to those forms which appear to be undescribed, of which the proportion is unusually great in this deposit. It has been already mentioned that only about one-half of these forms can be figured on the accompanying plate, and that the remainder will be given in the next number of the 'Journal.' It will probably be best to describe the forms here figured as they occur on the plate, in which the order of the Synopsis is followed. It must be borne in mind that some of the figures represent varieties of known forms, and that the two first belong to the two new forms observed by me in the Lillhaggsjön and Lüneberg deposits, and described in last number of the 'Journal.'

Fig. 1, Plate IV., shows two forms of *Eunotia Falx*, W. G. This very remarkable form needs no farther description beyond what will be found in the 'Transactions of the Microscopical Society,' vol. ii., p. 105. It has not yet occurred as a British form. It occurs with fresh-water species.

Fig. 2 represents an example of *Nitzschia Sigmatella*, W. G., also observed in the two deposits just named. But it occurs, as I have formerly stated, in the Mull deposit also; and since describing it I have found it, not only in the sand of Glenshira, but also in a recent gathering from Elchies, in Banffshire. It is therefore a British species, and, from the Banffshire locality, belongs to fresh water. (211.)

Fig. 3. *Cymbella truncata*, W. G. This pretty and well-marked species occurs in the Mull deposit, but sparingly. It is frequent in the Glenshira sand, and cannot, I think, be referred to any of the species of *Cymbella* or *Cocconema*, figured by Mr. Smith. Of course it is impossible, in a fossil deposit, to ascertain whether it be really a *Cymbella*, that is, free, or a *Cocconema*, that is attached by a stipes. It is possible and even probable, that this species has been noted on the Continent, but I have not been able to see any figure with which it can be safely identified. It is very uniform in its characters, always exhibiting the truncate or square ends from which I have named it. It is sometimes a good deal longer than the figure here given, which may be taken as typical.

It is a fresh-water form, and I have found it in many recent gatherings. (212.)

Fig. 4. *Amphora Arcus*, W. G. This fine form has not occurred in its entire state, but is frequent in the detached condition. The halves have precisely the form of a strung bow, often very elegantly curved. The striæ are coarse and moniliform. I have no certain means of ascertaining its habitat, but I suspect it to be marine. (213.)

Fig. 5. *Amphora incurva*, W G. This is also a very pretty form, most probably marine, and occurring detached, like the last. The striæ are very much finer than in *A. Arcus*. (214.)

Fig. 6. *Amphora angularis*, W. G. This is a striking form, and unlike the two preceding it occurs now and then complete, when it exhibits short square apices. It has a slight constriction in the middle. Habitat unknown. (215.)

Fig. 7. *Cocconeis transversalis*, W. G. This neat little form is distinguished from the other species of the genus by having fine transverse striæ. Its form is a pure oval. Habitat not known. (216.)

Fig. 8. *Cocconeis speciosa*, W. G. This form is nearly allied to *C. Scutellum*, but is usually smaller, and has somewhat of an angular form. The chief distinction lies in the striæ, which are much less numerous than in *C. Scutellum*, not exceeding 12 in ·001″, and they are formed of much fewer and much larger granules. Like *C. Scutellum* it occurs both with and apparently without a margin; and it might be taken for a variety of that species, but for the number and peculiar character of the striæ. I have closely searched several slides of marine origin, full of *Cocconeis Scutellum* of every degree of development, but I have not found in them one example of *C. speciosa*. I therefore regard it as a distinct species. (217.)

Fig. 9. *Cocconeis distans*, W. G. This very beautiful form is at once characterised by the equal size of the dots or granules, and their great distance from each other, so that it almost loses the aspect of striation. The form is purely oval. (218.)

Fig. 10. *Cocconeis costata*, W. G. This is a fourth new species of the genus, and is at once characterised by its very strong and entire costæ, which seem to be double lines or bands, expanding a little externally. It is a perfectly well-marked species. The habitat of this, as well as of the two preceding forms, is unknown, but they are probably of marine origin. (219.)

Fig. 11. *Eupodiscus*, qu ? *Ralfsii β*. This disc, which is not unfrequent, has a finely-radiate surface, the radii composed of small puncta, as in *E. Ralfsii*. But there is no trace of the peculiar blank spaces among the rays, which, so far as I know,

appear to be characteristic of *E. Ralfsii.* This latter species occurs with the usual characters; and I am inclined to regard the form, fig. 11, as distinct, but do not venture to give it as a species without further investigation. It is, in all probability, a marine form.

Fig. 12. *Surirella fastuosa β.* This species is finely developed, insomuch that it might almost be taken for a distinct species. I am disposed, however, to regard it only as a finely-developed *S. fastuosa*, as figured by Smith, and probably more truly typical than the form he has figured. It agrees well, except in being larger, with Kützing's figure. It is known to be a marine species.

Fig. 13. *Tryblionella constricta*, W. G. This pretty little form is very frequent in the deposit. Its form is that of *Cymatopleura apiculata*, but it is very much smaller, and has all the characters of *Tryblionella.* Striæ transverse, fine, but distinct. I am informed by Mr. West, that he long ago met with it in gatherings from Poole Bay. It is a marine form. (220.)

Fig. 14. *Amphiprora vitrea*, *β?* This fine form is frequent in the deposit. The peculiar arrangement of the median line, with its double curvature, at once strikes the eye. Indeed, on comparing it with the figure of *A. vitrea*, in the 'Synopsis,' it might be supposed to be a distinct species. But in the mean time, and until further examination, I refer it to the species named. It is a marine species.

Fig. 15. *Navicula birostrata*, W. G. This is a well-marked species. Form elliptical, with contracted, slightly produced, somewhat truncate apices. Striæ fine, somewhat inclined. It appears to vary a good deal in size. Habitat unknown. (221.)

Fig. 16. *Navicula rhombica*, W. G. This beautiful form is frequent in the deposit. Its form is rhombic, varying from short and rather broad, with obtuse apices, to long and narrow, with acute apices. Striæ very fine, transverse, quite distinct, even in balsam, which at once distinguishes it from *N. rhomboides.* The median line and central nodule are also quite different; and, in consequence, it differs totally in aspect from *N. rhomboides*, which is also present in the deposit, and with which it cannot be confounded. Habitat not known. (222.)

Fig. 17. *Navicula gastroides*, W. G. This form, when small, has some resemblance to *N. pusilla;* but is of much stouter habit, and has a brown colour, even in balsam. Besides this, it occurs much larger, being then more elliptical, while the smaller individuals are often almost orbicular. Striæ radiate and inclined. The median line and central nodule are very strongly developed, and the short apices appear as the

truncate extremities of the broad median line. Its habitat is not certainly known. (223.)

Fig. 18. *Navicula crassa*, W. G. This is a fine and well-marked species. Form elliptical, with a very slight inflexion before the obtuse apices. It varies considerably in size; has a very stout habit, and a brown colour in balsam. There is a large round spot in the centre, within which the two halves of the median line terminate in small round knobs, but do not meet. Striæ transverse, very fine, but distinct, not quite reaching the central line. It is frequent in the deposit, and is probably a marine form. (224.)

Fig. 19. *Navicula maxima*, W. G. This is a fine large form, much less frequent than any of the preceding. Form linear, elliptical, broad, with obtuse extremities. Striæ fine, transverse, reaching the central line. There seems to be a variety which is longer and narrower. Habitat unknown. (225.)

Fig. 20. *Pinnularia* (*Navicula*) *Gastrum*, Ehr. This little form is new to Britain, having been found by Ehrenberg in Mexican and North American gatherings. It is short, broadly lanceolate, with obtuse extremities slightly constricted. Striæ distinct, strongly radiate. The habitat is not given in Kützing, but it is probably marine. (226.)

Fig. 21. *Pinnularia apiculata*, W. G. This is another well-marked little species, which is not rare in the deposit. Form linear, narrow, contracted to small truncate apices. Striæ distant, transverse, hardly reaching the median line. Habitat unknown. (227.)

Fig 22. *Synedra Vertebra*, W. G. This form, which is very frequent in the deposit, belongs to the same division as *S. pulchella and S. acicularis*. It differs, however, from both these forms, which also occur in the deposit, and can thus be compared with it, in the remarkable relative width of the central portion, which has a somewhat curved outline, and the equally remarkable way in which it suddenly contracts to the very slender terminal portions. In the largest specimens, these are very long. Its form resembles that of certain vertebræ, and it has been named so as to recal this resemblance. Nodule strongly developed. Striæ very fine. The habitat of this species is unknown. (228.)

Fig. 23. *Synedra undulans*, W. G. This is, perhaps, the most remarkable of all the forms in the Glenshira sand. It is exceedingly elongated, and so slender that a perfect specimen has not yet occurred to me. It consists of a middle portion rather wider than the rest, tapering both ways to a very small width. From this point it extends on both sides,

for a long way, of uniform width, and terminates in small oval expansions. The narrow part has strong moniliform striæ, which, in the central and terminal expansions, are resolved, except just at the margin, into a general granulation. The margin is undulated, except for a short distance from each apex. It will be seen by one of the figures, which is not so long as some are, that the narrow part, on one side, without any part of the central long expansion, is frequently so long as to extend the whole way across the field, with a power of 400, that is, probably, 1-50th to 1-40th of an inch. This would make the length of the entire form to be probably from the 1-20th to the 1-15th of an inch, or more. This, with its extreme tenuity, accounts for its not occurring entire in a deposit carried by water, where it must have been constantly agitated. I have been informed by Mr. West, that a similar form, possibly of the same species, although shorter, occurs in a gathering from Port Natal, in the hands of Mr. Shadbolt. This curious Synedra is, therefore, a marine form, and I anticipate that it will be found recent on our own coasts. (229.)

Having now briefly described the new forms in the Glenshira sand, so far as they are here figured, I am compelled to postpone the remainder to the next number of the Journal, in which another plate will be required for them, as very nearly as many remain to be described as we have now been enabled to figure. In the meantime, besides the *Eunotia Falx*, which is not yet a British form, we have described 18 new forms, all from this one deposit, and one new to Britain. These, added to the list of known forms, make up the number of 229 species now recorded as occurring in the Glenshira sand, besides those to be hereafter noticed and figured.

It may be noticed here, that I intend to publish, as soon as the necessary figures can be prepared, a description of a very remarkable series of forms, occurring both in the Glenshira sand, and in various fresh-water gatherings, in which, indeed, I first observed them. They agree perfectly in general aspect, and the peculiar characters of the markings; but differ to a very surprising degree in form or outline. These may possibly constitute several species, and would certainly be considered as such by some authorities. But, both on account of their resemblance, or rather identity, in markings, and from the occurrence of intermediate or transition forms, by which the different types appear, in many cases at least, to pass into one another, there is some ground for regarding them as belonging to one species. Without deciding this question, I

have, for the convenience of description, grouped them under the name of *Navicula varians*, and I feel assured that the study of these forms will throw much light on the question, to which I have already directed attention, of the true value of form as a specific character.

I cannot conclude, for the present, without expressing the very great obligations I am under to Mr. Tuffen West, not only for the great care and accuracy with which he has drawn and engraved the figures, but also for the valuable assistance I have derived from his extensive and exact knowledge of the British Diatomaceæ in this long and laborious investigation. It is, indeed, fortunate for British microscopists that they have an artist who is not more distinguished for the beauty of his drawings than for his knowledge of the microscope, and his intimate acquaintance with the objects to be represented.

N.B.—Since the preceding pages were printed, I have observed a fragment of *Synedra undulans* in a slide from Poole Bay, sent to me by the Rev. W. Smith. I have no doubt that the gathering, if searched, will yield entire specimens. I am also informed by M. de Brébesson that he has seen the same form in marine gatherings from Brest, but supposed it to be *S. gigantea*, Lobarzewsky, from which species, however, he now finds it to be quite distinct.

I may take this opportunity of mentioning that the following species must be added to the list of known forms in the Glenshira sand, as I have noticed them quite recently.

230. Trybleonella angusta.
231. ,, Scutellum.
232. Amphiprora elegans, Bleakley.
233. Gomphonema cristatum.
234. Mastogloia apiculata. Sm.

No. 232 is a splendid marine form, observed last spring by Mr. Bleakley, near Harwich. No. 234 is a very fine marine species, which occurs in great abundance along with 232 at Poole Bay. I have understood that Mr. Smith has named it as above, but that it may possibly be referable to another species.—W. G.

A few Remarks on a Paper, read before the Royal Society by Dr. J. W. Griffith, *on the* Angular Aperture *of* Object-Glasses. By Dr. F. d'Alquen.

In the last number of the 'Microscopical Journal' an abstract of the above paper was given, and, if you think the subject of sufficient interest to your readers, I should feel obliged if the following observations could appear in your next number, in refutation of the only novel point in Dr. Griffith's paper.

Mr. Wenham states, in one of his valuable papers, that the markings on test objects become visible by a contrast of light; and the attention of the reader will at once be brought to the point upon which the whole question hinges, when I add that the gist of Dr. Griffith's paper is an attempt to show how this contrast of light is produced, and why the markings can only be seen under an object-glass of large angular aperture, and not with one which is deficient in this respect, however great its magnifying power may be. In answering these propositions the Doctor states, in substance:—The markings, those on a valve of a *Gyrosigma*, for instance, being in reality depressions, the light, on passing through them, suffers greater refraction from the perpendicular than the set of rays corresponding to the undepressed, thicker, and therefore more highly refractive portion of the valve, and we have thus two sets of rays of different degrees of obliquity—the former of which, as the most oblique, is tilted out of the field of the microscope, whilst the second set is admitted, if the angular aperture of the object-glass is sufficiently large; and thus is the contrast of light produced which renders the markings visible. If the aperture of the object-glass is deficient, no contrast is produced, and the markings remain invisible; but the explanation of this point is the author's difficulty, and it is not easy to single out in precise language his meaning. At all events, the "*rem invisam verba sequuntur*" we cannot apply to this part of his explanation, which, in so acute an observer as Dr. Griffith generally is, can only be accounted for by his labouring under the difficulty of having to reconcile facts to a preconceived speculative theory of his own.

It is self-evident, if the tilting out of one set of rays were the cause of the markings becoming visible, that this must equally, and even more readily, take place under an object-glass of small aperture, because not only the rays tilted out from the object-glass with large aperture, but even those admitted by it, as far as they exceed the angular aperture of an object-glass with deficient aperture, are naturally excluded, or tilted out with regard to the latter; in fact, no rays could by any possibility become excluded from an object-glass, with large aperture, which were not *eo ipso* also tilted out from an object-glass with deficient aperture: it is therefore clear, as experience tells us, that certain markings cannot be seen with such a glass under any circumstances, that the contrast of light is not produced in the manner stated, nor can the tilting out of certain rays, *if it takes place at all*, be the cause of rendering the markings visible. This objection loses, also, nothing of its force when the author states, that the angular aperture must

be greater as the markings are more delicate, *because* it would require greater obliquity of the light to exclude one set, and the other would be too oblique to enter the object-glass, unless it be of corresponding large aperture. Now I do not see the cogency of this, because, in this sentence, if he had said, that the obliquity of light required must be greater if the aperture was large, I readily could understand him, though the inverse would be equally clear, viz., that the obliquity of the light required for the exclusion of one set of rays would be less, if the aperture were small; but why the obliquity must be greater as the markings are more delicate I cannot understand, nor has the author given us any reason for it, but assumes it as a natural consequence, as implied by the word "because." If there was a law in optics, that, by greater obliquity of light, the ratio of con- or di-vergence *between* two rays was increased, I readily could admit the pertinence of the above remark; but that would be saying that the refractive index of any medium varied with the angle of incidence, while we know that the sinuses of the angles of incidence and refraction stand, with regard to the same medium, always in a constant proportion. The greatest obliquity of light is therefore separate, the two sets of rays not more than they are under ordinary illumination. Further, if the second set is likewise too oblique to enter the object-glass, if not of corresponding large aperture, it would follow, that, under an object-glass of deficient aperture, both sets of rays, those corresponding to the depressed (the first), as well as those corresponding to the undepressed portion of the valve (the second set), are excluded, and thus nothing at all of the object could be seen, which is simply absurd. In disregard of the simple and plain fact that the efficacy of the greater over the lesser aperture depends upon the *admission* and not upon the *exclusion* of certain rays, the author goes on to say: "The most difficult point has been to explain how it is that an object-glass of large aperture will render markings evident which were not visible under an object-glass of smaller aperture." I freely admit that, as I have shown, if we adopt the author's theory, the explanation is not only difficult but impossible. Nor does this difficulty vanish, as he states it does, when we recollect that the additional rays admitted by the larger aperture are more oblique; because, how can the admission of additional rays prove the tilting out of others, which is the point at issue? Observe: *hence* one set of rays will be refracted from the field (pray, why?), whilst the other will enter. In my opinion, there is no *sequitur*, which that very convenient little word "hence" seems to imply, but the same gratuitous assumption as we have

already noticed before. Moreover, it must not have appeared quite conclusive to the author himself, because he continues: "Or to simplify this most important point, the object may be regarded as illuminated by two sets of rays, one corresponding to those admitted by the object-glass of the smaller aperture, the other set, to these plus those admitted by the excess of angular aperture of the second over the first." Now we may not only regard with the author the object as thus illuminated, but we know that such is actually the case, and that the efficacy of the larger aperture over the lesser depends simply on the admission of additional rays which were too oblique to enter the latter; but simple as this is, we must ask again, how can the admission of additional rays, here assumed, prove the tilting out of others? Mark the answer: the first set not being sufficiently oblique to allow a portion of them being refracted beyond the angular aperture of the first object-glass, while the second set are so. Now every one will admit that this illustration proves nothing, because the rays admitted by the first object-glass are as oblique with regard to its angular aperture, and the practicability of becoming tilted out as the rays entering the second to its corresponding larger aperture.

Another objection which is, *à priori*, as palpable as those I have already noticed is this: if the markings are rendered visible, by the tilting out of certain rays, it would follow, as the fewer rays will be tilted out the greater the aperture, that the markings, instead of becoming more distinct, must have their distinctness impaired in the same proportion as the angular aperture is increased; yet experience tells us that the reverse is the case. If we further assume that the illumination remains the same, the more we increase the angular aperture, the more it would become impossible to realize the alleged conditions for rendering the markings visible; and with every degree added to the aperture, the markings ought to get fainter, which is contrary to the fact. Lastly, from the excessive minuteness of the depressions, it appears to me highly improbable that the difference thereby occasioned in the thickness or substance of the valve should be the cause of giving a different refractive index to different portions of the valve; and I feel more inclined, with other observers, to attribute the modification which the light undergoes, on passing through it, to peculiarities in the structure of the markings themselves. However, let us proceed from assertions and counter assertions to practical experiment, the ultima ratio in an inductive science.

By means of a small pipe of an injecting syringe, with an

opening of 1·30″ diameter, fixed to a small glass tube in an adaptor, in the place of the achromatic condenser, I illuminated the prepared valve of a Pleurosigma Balticum, mounted dry, by as *direct* and *straight* a light as could be done; and under an object-glass (¼), whose aperture I had reduced to 50°, both sets of striæ were visible. I next increased the aperture, by substituting a larger stop, to 65°, and the markings became much more distinct. A similar result was obtained by successively increasing the aperture to 75°, and, lastly, to 90°, when the distinctness of the markings was most strikingly increased, and the whole object more brightly illuminated. It cannot be doubted that a similar result would have been obtained, had I been able still to increase the aperture of the object-glass; and if the author's theory was correct, in doing so, the light being straight, the markings ought to have become fainter and fainter, and disappeared entirely at last, as, with every degree added to the aperture, fewer rays could become refracted out of the field of the microscope.

This experiment proves further, the light being direct and straight, that the obliquity of the emerging rays must be due to the peculiar structure of the markings, and does not arise from a difference of density, as assumed by the author; and further, that the visibility of the markings depends upon aperture and not upon illumination, though the latter may serve to increase their distinctness, while, without the former, any kind of illumination would remain ineffective.

A similar experiment, previously made, having made it probable that the set of rays corresponding to the depressions did not pass through them at all, but was completely intercepted, and either refracted or reflected into the substance of the valve towards the margin of the depressions, thus leaving the latter themselves dark, it was desirable to devise another experiment, on such a scale as would admit of a practical proof regarding the phenomena concerned. For this purpose, I put a thin layer of Canada Balsam, nearly deprived of its turpentine, so that it hardens as quickly as it cools, on an ordinary glass slide, and, with the delicate bristles of a seed of an Erodinæ, I made a number of minute markings respecting depressions while the balsam was yet soft, but not so soft as to stick.* It being admitted that the markings on the gyrosigma, for instance, consist of depressions in the siliceous substance of the valve, and Canada Balsam having almost the same refractive index as silica, agreeably to Mr. Wenham's

* If the balsam is already too hard, it cracks, the surface of the depressions, becomes uneven, and forms new sources of refraction, which is also the case if the markings penetrate down to the glass.

experience, I had thus, as nearly as I could, imitated, on a large scale, the valve of a *Gyrosigma*. On examination of the slide thus prepared under the microscope, I found it covered with dark spots or dots, surrounded by a very luminous margin or ring. This may even be seen if the slide is laid on white paper and closely examined; each indentation produced in the layer of balsam will instantaneously be followed by a shadow or dark spot on the paper, with its halo.

Now, if the markings had, in this instance, been as close and near to each other as is the case in the valve of a *Gyrosigma*, for instance, this experiment would have lost a great deal of its interest, because, in that case, the luminous rings would have become confluent, if I may borrow this expression, and invisible, by being lost *in*, and forming the general illumination of the undotted portion of the layer; but, as seen now, each opaque spot has it own halo, which is of course produced by the interception of the rays corresponding to the depressions, which, instead of passing through them, emerge at their margins, thus forming a luminous ring, leaving the depressions themselves dark. Now, be it well observed, this is the identical set of rays which, according to Dr. Griffith's theory, is refracted out of the field altogether; and it is evident, if that had been the case in this instance, the luminous rings would not have been formed at all. But in order further to prove that no rays are tilted out of the field proceeding from the depressions, I drew out before the blowpipe a small glass tube in a very fine hair-like filament, and this delicate condensor I held directly over the opaque depressions, without, however, receiving any evidence of rays issuing therefrom, while the portion above the halo was likewise brilliantly illuminated. This is, I think, the most direct way of disproving Dr. Griffith's hypothesis. If the phenomena witnessed in this instance are the same as occur in the examination of the valve of a gyrosigma, the manner in which the markings are displayed and rendered more or less distinct, accordingly as the aperture of the object-glass is large or small, finds an easy and natural explanation in the difference of the aperture itself, and its ordinary operation. The luminous rings are formed mainly of oblique rays proceeding from the lowest point of the depressions upwards and round them; the greater the aperture, the more oblique rays enter, and the greater the contrast, and *vice versâ*. If we depress the object-glass gradually, we can trace the rays down to the point from which they proceed—the dark spot *gradually* disappears, and is at last replaced by a very brilliant point, from

which the rays seem to radiate in all directions; if we depress still further, this luminous spot also disappears, and we see nothing but the uniformly-illuminated layer of balsam. If the aperture of the object-glass is small, the luminous rings are either not seen at all, or fainter, in proportion to the extent of the aperture; and, on depressing the object-glass, the opaque spots disappear at once, and we cannot trace the rays of the ring down to the lowest point. For the sake of greater accuracy, I made these observations with the same object-glass, the aperture of which gradually diminished by stops. It is also necessary that, during the different trials, we should always have the same focus; this cannot be done by looking at the opaque depressions, but by bringing any other fine mark or scratch on the surface of the layer always first to its exact focus. Candlelight is preferable to daylight. I did not use a condensor, but the ordinary plane-reflecting mirror, being anxious to study the phenomena under their most simple conditions. At certain inclinations of the mirror, the dots become much elongated, so that one can easily understand how rows of dots, if close together, produce the appearance of lines. I have thus not only proved that the theory advanced by Dr. Griffith is untenable, and contrary to fact, but also shown, or made it at least probable, how the contrast of light is produced which renders the marking visible.

On the Structure of NOCTILUCA MILIARIS. By THOMAS H. HUXLEY, F.R.S.

AMONG the many striking and beautiful appearances presented by the Ocean, there is none, perhaps, which has more attracted the attention both of the naturalist and of the casual observer, than the silvery, sparkling, phosphorescent light, which may often be seen on dark nights, illuminating the track of every boat and defining the contours of the waves as they break upon the shore.

After long serving as a fertile subject of doubt and discussion, it is now well known that this luminosity proceeds from many sources; in the main, from living invertebrate animals—Protozoa, Polypes, Medusæ, Annelids, Crustaceans, &c. Among these again, the chief and most important part is played, as was first shown in the middle of the last century by M. Rigaut, and again in 1810 by M. Suriray,* by a singular and anomalous creature of very simple organization, the *Noctiluca miliaris*.

* See *Quatrefages, l. c.* I regret that I have not access at this moment to M. Suriray's paper.

According to M. Suriray the *Noctiluca* is a spherical gelatinous mass, provided with a long filiform tentacle or appendage, presenting a mouth, an œsophagus, one or many stomachs and ramified ovaries, and thus possessing a certain complexity of organization. De Blainville confirmed Suriray's account, and placed *Noctiluca*, without doubt most erroneously, among the Diphydæ. On the other hand, Van Beneden Verhaeghe and Doyére, denying the relation of *Noctiluca* with the Acalephæ—and conceiving its organization to be of a much more elementary character—relegated it to the Rhizopoda.

To this doctrine M. de Quatrefages also attaches the weight of his authority in his valuable essay '*Observations sur les Noctiluques*,' published in the Annales des Sciences Nat. for 1850. M. de Quatrefages does not admit the existence of any true mouth or intestinal canal, and considers that the so-called stomachs are nothing but '*vacuoles*' similar to those observed in the Rhizopoda and Infusoria.

In a short memoir published in Wiegmann's Archiv. for 1852, however, that excellent and most accurate observer, M. Krohn, carried the subject a stage further, and showed that the organization of *Noctiluca* is more complex than has been supposed. Krohn carefully describes and figures the mouth of *Noctiluca* and the long vibratile *cilium*, which he was the first to observe, proceeding from it. Krohn draws particular attention to the oval body first described by Verhaeghe, which he considers to be the homologue of the '*nucleus*' of the infusoria; and describes the ejection of fæcal matters. Arranging the *Noctiluca* among the Protozoa, Krohn points out some interesting structural analogies with *Actinophrys* and *Paramæcium*.

I will now proceed to detail the results of my own observations.

Noctiluca miliaris (Plate V. figs. 1, 2) may be best described as a gelatinous transparent body, about 1-60th* of an inch in diameter, and having very nearly the form of a peach; that is to say, one surface is a little excavated and a groove or depression runs from one side of the excavation half way to the other pole (*échancrure*, Quatrefages. *Frauenbnsenähnliche Einbucht*, Krohn). Where the stalk of the peach might be, a filiform tentacle, equal in length to about the diameter of the body, depends from it, and exhibits slow wavy motions when the creature is in full activity. I have even seen a

* The extremes of size are given by Krohn as 1-7 — 1 millimetre = 1-170 — 1-25 inch about.

Noctiluca appear to push repeatedly against obstacles, with this tentacle.

The body is composed of a structureless and somewhat dense external membrane, which is continued on to the tentacle. Beneath this is a layer of granules or rather a gelatinous membrane, through whose substance minute granules are scattered without any very definite arrangement. From hence arises a network of very delicate fibrils, whose meshes are not more than 1-3000th of an inch in diameter (fig. 6), and these gradually pass internally,—the reticulation becoming more and more open—into coarser fibres, which take a convergent direction towards the stomach and *nucleus*. All these fibres and fibrils are covered with minute granules, which are usually larger towards the centre.

Quatrefages states that these granules may be seen to glide from the centre to the circumference, and *vice versâ*, propelled by the contractions or expansions of the transparent matrix in which they are imbedded; that new fibrous processes (*expansions*) arise on the central mass and unite, dividing and subdividing, with the neighbouring ones—and that if the creature be irritated, the fibres and fibrils become detached from the investing membrane, and are drawn in towards the mouth "like threads of a very viscid liquid, which retract slowly after being broken."

All these appearances may be very readily seen; but I am strongly inclined to believe that the greater part of them are abnormal states, and that in their natural and perfectly unaltered condition, the fibres and fibrils are perfectly quiescent, and present nothing to be compared with the protean movements of the *Amœbæ*. In their perfectly fresh and unchanged state, in fact, the fibrous network is by no means so obvious as it usually appears, and in such specimens I have been unable to convince myself that the granules undergo any change of place—certainly there is no protrusion and retraction of processes to be compared with that which takes place in the Rhizopoda.*

The oral aperture has been satisfactorily described by Krohn. Supposing the animal to lie upon its oral face (the attitude it commonly assumes), with its tentacle forwards—the oral aperture appears as a sort of half oval, with a nearly straight edge anteriorly, and a deeply-curved outline posteriorly (fig. 4).

* Krohn states, that he could hardly ever cause the *Noctilucæ* to contract by mechanical or chemical irritation; but that he once saw one which repeatedly contracted before falling into the permanently wrinkled and collapsed condition, into which they so readily pass.

The anterior edge is not quite straight, but is formed by two ridges, apparently of a harder substance than the remainder of the outer membrane, which run up on the two sides of the fissure, and unite, forming a very obtuse angle, open anteriorly, in the base of the tentacle.

The latter is a subcylindrical filament of 1-1800th inch diameter, more or less flattened, sometimes quite flat at its free end, which is rounded at the apex. It is a little broader at its base than elsewhere, and consists of an external structureless membrane continuous with the general investment, and of an internal substance, which is so marked by transverse granular lines, as very closely to resemble a primitive fibril of striped muscle. I agree with Krohn that the striation is not in the external membrane, as Quatrefages states.

From the bottom of the oral cavity a very delicate filament (fig. 3), which exhibits a rapid undulating motion, is occasionally protruded, and then suddenly withdrawn. Krohn, who first discovered this singular organ, considers that it plays an important part in sweeping nutritive matters into the oral cavity, and there can be little doubt that such is the case. I would warn future observers not to be easily discouraged in their search for this organ. I had sought for it in at least fifty individuals without success; and nothing but the firm confidence in M. Krohn's accuracy, with which frequent working over his ground has inspired me, led me to persevere until I had discovered it. Among the great numbers of *Noctilucæ* which I examined, however, I did not observe half a dozen which presented a good view of the *cilium*.

Under these circumstances, I do not comprehend how it is that M. Krohn should have overlooked a very remarkable structure which requires no such sharpness of vision as that to which I have just alluded. I refer to an S-shaped ridge arising close to the right extremity of the anterior oral margin above described, and passing down on the right side of the oral aperture to form its lateral and posterior boundary.

This ridge is horny-looking, and is considerably produced in its middle portion into a tricuspid prominence (fig. 4 *d*), for which I know of no better name than a 'tooth.' This tooth is about 1-7000th in. high; its middle cusp is stronger than the other two, and bifid, while the posterior has a slight pointed heel. I have never observed any movement in this tooth-like body.

Behind it the oral aperture narrows to inclose what may be termed a *post-oral* space, and then widens again; the elevations bordering this post-oral space are continuous with those

which form the sides of the triangular groove or fissure, which has been above described as running up on one side of the body (figs. 1, 2 *b*). In the midst of this flattened post-oral space there is a small funnel-shaped depression, which I am strongly inclined to believe is an anal aperture (fig. 3 *f*).

The oral aperture leads into the granular mass of the alimentary cavity, from which the fibres and fibrils radiate. Quatrefages says :—

"At one part of the groove of which we have spoken, and near the point of insertion of the appendage, there is always a little mass of different substances, sand, &c., which can only be detached with great difficulty. When this has been done these foreign bodies are seen to have simply adhered to a semi-transparent, granular substance, which projects like a hernia, so to say, from a little orifice (mouth of authors) by which the membranes are perforated. This external substance is continuous with a much larger internal mass of the same nature, whose dimensions and form vary in each individual.

"However carefully I have sought for a digestive canal of any kind, I have never been able to discover anything of the sort; but I have very frequently seen more or less considerable vacuoles in the midst of this substance. It is these most probably which have been regarded as stomachs by MM. de Blainville and Suriray."

I have never seen this projecting mass nor any foreign bodies in the position indicated by Quatrefages, in perfectly fresh specimens. In those which had undergone alteration, on the other hand, such an appearance was frequent, but it invariably appeared to me to result from a partial extrusion of the contents of the stomach.

The appearance of 'vacuoles,' on the other hand, is almost invariable in fresh specimens; but I cannot think that these clear spaces, which are defined by a well-marked membranous wall, have any analogy with the shifting 'vacuoles' of the Infusoria and Rhizopods. It appeared to me, on the other hand, that the oral cavity led directly in a definite stomach, whose walls are capable of very great local dilatation, such dilatations, connected by very narrow pedicles with the central cavity, then having all the appearance of independent vacuoles (fig. 3 *e*). The accumulation of granules around the central mass greatly contributes to this appearance. Like Krohn, I frequently noticed large Diatomaceæ and other foreign matters in these gastric pouches.

Not only does all I have observed lead me to believe that *Noctiluca* has a definite alimentary cavity, but I am, as I have said above, inclined to think that this cavity has an excretory aperture distinct from the mouth. The funnel-shaped depression in the post-oral area, in fact, always appeared, when I could obtain a favourable view, to be connected with a special process of the stomach. On one occasion I observed

the sides of this process to be surrounded by fusiform transversely-striated fibres or folds, I could not determine which.

Krohn states that he repeatedly saw the *egesta* voided 'in the neighbourhood of the groove of the body,' but he could not determine at what exact point, and he inclines to think it must have taken place through the mouth.

I am equally unable to bring forward direct evidence on this point, and my belief in the existence of a distinct *anus* is founded simply on the structural appearances.

In front of and above the gastric cavity is the *nucleus* (*c*), described by Verhaeghe and Krohn. This is a strongly refracting, oval body of about 1-460th inch in length, which, by the action of acetic acid, assumes the appearance of a hollow vesicle. The anterior radiating fibres pass from it; the posterior from the alimentary canal.

Quatrefages and Krohn consider that a process of fissiparous multiplication takes place in *Noctiluca;* both of these observers having found double individuals, though very rarely. According to the latter writer, division of the body is preceded by that of the *nucleus.* I have not had the good fortune to meet with any of these forms, and the only indication of a possible reproductive apparatus which I have seen consisted of a number of granular, vesicular bodies (fig. 5 *h*), of about 1-2000th inch in diameter, scattered over the surface of the anterior and inferior part of the body.

Such is what repeated examination leads me to believe is the structure of *Noctiluca;* but if the preceding account be correct it is obvious that the animal is no Rhizopod, but must be promoted from the lowest ranks of the Protozoa to the highest.

The existence of a dental armature and of a distinct anal aperture, are structural peculiarities which greatly increase the affinity to such forms as *Colpoda* and *Paramœcium*, indicated by Krohn. *Noctiluca* might be regarded as a gigantic Infusorium with the grooved body of *Colpoda*, the long process of *Trachelius*, and the dental armature of *Nassula* united in one animal.

On the other hand, the general absence of *cilia* over the body, and the wide differences in detail, would require the constitution of at least a distinct family for this singular creature.

Economy *of* Closterium Lunula. By the Hon. and Rev. S. G. Osborne. Communicated by Jabez Hogg, Esq.

The division of labour-principle holds as good amongst microscopists as amongst any other workers in the fields of

knowledge. I have devoted now for some months, and on an average several hours almost daily, to the study of some of the Desmidieæ, especially the *Closterium Lunula.* With increased objective powers and the use of improved methods of illumination, I have arrived at results which may, I think, interest many of your readers.

As to the *Closterium Lunula*, I have ascertained that the best view of its circulation and the *cilia* which gives it its impulse, is obtained by the use of full sunlight transmitted through the combination of coloured glass, proposed by Mr. Rainey, and adapted to an achromatic condenser. I have used a 1-6th objective of Ross's, his 1-4th with the Rainey moderator as illuminator. In diagram A, I have given a rough sketch of a specimen of the *C. Lunula;* with the above arrangement of the microscope, using also a deep eye-piece, I have again and again seen the cilia in full action along the edge of the membrane which encloses the endochrome; I have seen them also, but not so distinctly, along the inside of the edges of the frond itself. Their action is precisely, to my eye, the same as that in the branchiæ of the mussel. There is the same wavy motion, and as the water dries up between the glasses in which the specimen is enclosed, the circulation gets fainter at the edges, and the *cilia* are seen with more distinctness.

In the diagram, I have drawn a line at *b* to a small oval mark; these exist at intervals, and more or less in number over the surface of the endochrome itself, beneath the membrane which invests it. They seem to be attached by a small pedicle, are usually seen in motion on the spot to which they are thus fastened; from time to time they break away, and are carried by the circulation of the fluid, which works all over the endochrome, to the chambers at the extremities, there they join the crowd of similar bodies, each in action within those chambers, when the specimen is a healthy one.

The circulation, when made out over the centre of the frond, for instance at *a*, is in appearance of a wholly different nature from that seen at the edges. In the latter, the matter circulated is in globules, passing each other, in distinct lines, in opposite directions; in the circulation as seen at *a*, the streams are broad, tortuous, of far greater body, and passing with much less rapidity. To see the centre circulation, I have used a Gillett illuminator and the 1-6th power, so working the fine adjustment as to bring the centre of the frond into focus; then almost losing it by raising the objective; after this, with great care working the milled head till I just

make out the dark body of the endochrome; a hair's-breadth more adjustment gives me this circulation with the utmost distinctness if it is a good specimen. It will be clearly seen, by the same means, at all the points where I have put spaces, and from them, may be traced, with care, down to both extremities.

The endochrome itself is evidently so constructed as to admit of contraction and expansion in every direction; at times the edges are in semi-lunar curves, leaving interrupted clear spaces visible between the green matter and the investing membrane; at other times, I have seen the endochrome with a straight margin, but so contracted as to leave a well-defined transparent space, along its whole edge, between itself and the exterior of its sac. It is interesting, in this case, to keep changing the focus, that at one moment we may see the globular circulation between the outer and inner case, and again the mere sluggish movement between the inner case and the endochrome.

I have now not the slightest doubt but that the loose bodies in the chambers at each extremity of the frond are brought, as I have described above, from the exterior of the endochrome, by the external current; what they are I do not profess to say; they are as the rule *diamond-shaped*, when at rest.

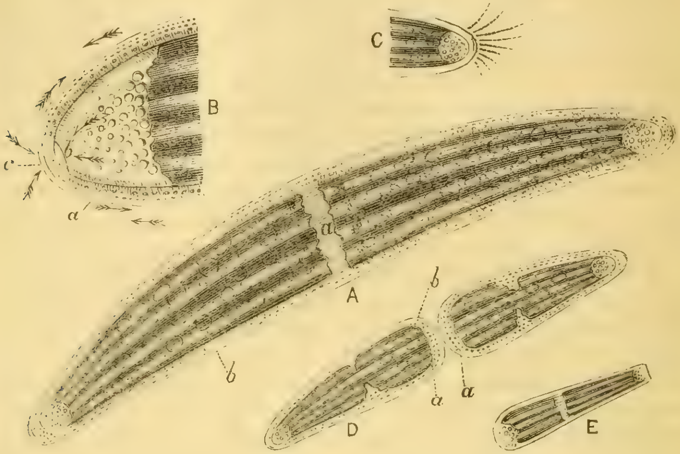
In B, I have given an enlarged sketch of one extremity of a *C. Lunula*. The arrows within the chamber pointing to *b*, denote the direction of a very strong current of fluid I can detect, and occasionally trace most distinctly; it is acted upon by cilia at the edges of the chamber, but its chief force appears to me to come from some impulse given from the very centre of the endochrome. I have seen the fluid here acting in positive jets, that is with an almost arterial action; this it is, which, according to the strength with which it is acting at the time, propels the loose floating bodies at a greater or less distance from the end of the endochrome; the fluid thus impelled from a centre, and kept in activity by the lateral *cilia*, causes strong *eddies*, which give the twisting motion we see to the said free bodies. The line — *a*, in this diagram, denotes the outline of the membrane which encloses the endochrome; on both sides of this I can detect *cilia*. The circulation exterior to it passes and repasses it in opposite directions, in three or four distinct courses of globules; these, when they arrive at — *c*, seem to encounter the fluid *jetted* through an aperture at the apex of the chamber; this disperses them so that they appear to be

driven, for the most part, back again on the precise course by which they had arrived; some, however, do enter the chamber: occasionally, but very rarely, I have seen one of the loose bodies escape from within, and get into this outer current, in which it is carried about, until it becomes adherent to the side of the frond. I am now quite satisfied that in the case of the specimen diagram C (p. 235, Vol. II.), to which I referred in your last number, the pressure of the glass in which the specimen was enclosed had forced the endochrome so far up into the chamber, that the jetting action of the fluid, nominally acting within the frond, was thus made to play exterior to it.

With regard to the propagation of the *C. Lunula*, I have never seen anything like *conjugation*, but I have repeatedly seen what I shall now describe—increase by self-division.

Let me request your readers to observe the diagram D, but for the moment to suppose the two halves of the frond, represented as separate, to just overlap each other; I have watched for hours the process of complete division; one-half has remained passive, the other has had a motion from side to side, as if moving on an axis at the point of juncture; the separation has become more and more ardent, the motion more active, until at last with a jerk one segment leaves the other, and they are then under view as I have drawn them. It will be seen, that in each segment the endochrome has already a *waist;* but there is only one chamber, which is the one belonging to one of the extremities of the original entire frond. The globular circulation for some hours previous to subdivision, and for some *few* hours afterwards, runs quite round the obtuse end of the endochrome — *a*, by almost imperceptible degrees; from the end of the endochrome, symptoms of an elongation of the membranous sac appear, giving a semilunar sort of chamber; this, as the endochrome elongates, becomes more defined, till it has the form and defined outline of the chamber at the perfect extremity. The obtuse end — *b* of the frond is at the same time elongating and contracting; these processes go on; in about five hours from the division of the one segment from the other, the appearance of each half is that of a nearly perfect specimen, the chamber at the new end is complete, *the globular circulation exterior to it becomes affected by the circulation from within the said chamber;* and, in a few hours more, some of the free bodies descend, become exposed to, and tossed about in the eddies of the chamber, and the frond, under a 1-6th power, shows itself in all its full beautiful construction. E is a

diagram of one end of a *C. didymotocum*, in which I saw the same process.



I have now given you, in as plain a manner as I can, the result of my further observations; I invite other lovers of the science to test their truth; I shall be most glad of any corrections their greater experience and better skill may afford; at any reasonable notice I will send to any of your readers, a stock of specimens. The best I obtain are from Branksea Island—Poole Harbour: the best specimens to examine are those with the lightest green endochrome, and in which the *furrows* are most marked. I am so engaged I will not at this time put forth my theories in connection with this *Desmidium*, for I could only do so in a hasty and crude manner. I can with truth say, that I am more than ever convinced that the microscope has not yet shown me any object so beautiful, so wonderful, and which has so amply repaid all the trouble I have bestowed upon it.

I would only now add an invitation to brethren of the lens to try their skill, and the power of their instruments on *Euastrum Didelta*; they will, if I am not mistaken, find in it wonders, which, when developed, may rival my pet *C. Lunula*.

TRANSLATIONS, &c.

On the Male reproductive Organs of CAMPANULARIA GENICULATA (*Laomedea geniculata*, Lam). By Dr. MAX S. SCHULTZE, of Greifswald. (From Müller's Archiv. fur Anat. und Physiol. 1850.)

THE propagation of *Campanularia geniculata*, described by Lovén in 1837,* differs essentially from the mode of increase observed by V. Beneden in several species of the same genus. In the former species ciliated embryos are produced within axillary capsules, from vesicles presenting all the parts of an *ovum*, and after a distinct process of segmentation. These embryos, after they have quitted the tunic by which they are surrounded, and which resembles an incompletely developed polype, swim about free for some time, and precisely resemble the embryos of *Medusa aurita;* they then affix themselves, and grow into a polype resembling the parent animal. In the *Campanulariæ*, however, described by Van Beneden, medusoid creatures with tentacles, digestive and sensitive organs, are produced, also in axillary capsules; and which after quitting the capsule swim about free in the water and behave exactly like *Medusæ*. These were regarded by Van Beneden as the embryos. He considers that they are produced from *ova*, and supposes that they subsequently affix themselves, and after the obliteration and metamorphosis of some of their organs become *Campanulariæ*. Other observers on the contrary, particularly Nordmann and Dujardin, regard these medusiform products of the *Campanulariæ* as the developed forms of those polypes, believing that in the *Medusæ* arising in the asexual way, sexual organs are afterwards developed. The *Campanulariæ* consequently would have to be regarded as corresponding to the *Strobila* form of *Medusa aurita*.

Although the decisive proof of Van Beneden's view is still wanting, inasmuch as he has not demonstrated the egg-nature of the germ of the medusiform animalcules, as well as the impregnation by semen necessary, in this case, for their development, and as he, as well as Lovén, did not discover male seminiferous organs in his *Campanulariæ*, still it cannot

* An observation of Kölliker's should here be noticed. He saw in *Pennaria Cavolinii* capsules with spermatozoids (formation of spermatic filaments in vesicles). It is unfortunate that these capsules and their contents should not have been more minutely described; nor has the importance of the observation been generally recognized.

be denied that a correspondence in the mode of propagation of the *Campanulariæ*, described by Lovén and Van Beneden, is more readily perceived in an explanation of it according to the views of the latter, than when it is explained according to those of Dujardin. I have not, unfortunately, had an opportunity of observing *Campanulariæ* with medusiform offspring, and consequently must at present refrain from expressing any judgment in favour of one view or the other. But it appears to me that everything depends upon the determination of the fact, whether the medusiform animals are also produced by sexual propagation like the ciliated embryos of *C. geniculata*. If true egg-germs, with the usual transitionary forms into embryos, are found in the axillary capsules of Van Beneden's *Campanulariæ* (as stated by that author), and in other capsules, spermatozoids, in the way I am about to describe as obtaining in *Campanularia geniculata*, no farther doubt, perhaps, could be entertained with respect to the embryonic nature of the medusiform offspring; and their development into sexual, self-propagative *Medusæ* would, according to all known analogies, have to be regarded as impossible; but if, on the contrary, it is found that the *Medusæ* arise in an asexual way in the capsules, and that analogous spermatic capsules do not occur at all, we should in that case expect to witness the development of sexual parts only in the *Medusæ*, and consequently should have to regard the *Campanulariæ* merely as developmental forms of *Acalephæ*. In *Campanularia geniculata*, then, the polypoid envelopes of the *ova* and embryos, as well as the spermatic globules presently to be more particularly described, should necessarily be regarded as analogous to the *Medusæ*, although they never become free, nor exhibit any kind of movement whatever beyond a slight motion of the tentacles, and are wholly incapable of receiving nutriment.

In the genus *Campanulariæ*, therefore, we have true polypes, whose representatives are *Campanularia geniculata* and others, which might be regarded only as developmental conditions of an *Acalepha*, exactly as is the case with the species of *Coryne*, many of which, as for instance *C. squamata*, develop ova and spermatic capsules, which never separate from the polypes, but after being emptied of their contents become detached; whilst in others, as in *Coryne aculeata*, these capsules are detached before the complete development of the *ova* or of the *semen*, and swim about under the form of *Medusæ*, in which the sexual organs are not developed till afterwards.

Let us now return to our observations. The male organs of the *Campanulariæ*, containing the spermatic fluid, have not

hitherto been recognized. Neither Lovén nor Van Beneden in their numerous researches on the *Campanulariæ* have seen them, any more than the older observers. But in Steenstrup's 'Researches on the Hermaphroditismus,'* I find a short notice with respect to them. He says, "In the genera *Tubulariæ*, *Eudendrium*, and *Campanulariæ*, I have always found the 'nurse'-polypes to present only one sex; and in *Campanularia geniculata*, semen was never formed except in precisely those individuals which were developed under the same conditions as the true females which furnish the *ova*."

Krohn† and Kolliker‡ have given some notices with respect to male organs in other Sertularina. The former observed spermatic capsules, corresponding to the ovicells in position and figure, although growing upon separate stems, in *Pennaria Cavolini*, *Eudendrium racemosum*, and *Plumularia cristata;* and the latter also in *Sertularia abietina*. Precise descriptions and figures of these organs, however, are wanting; and with regard to the development of the spermatozoids, Kölliker merely mentions that they appear to be produced from elongating vesicles, and figures them accordingly as they exist in *Sertularia abietina*.

As I have had abundant opportunity of observing *Campanularia geniculata*, I directed my attention at once to the reproductive organs and the propagative function, and was fortunate enough, in the autumn of 1849, to detect the male reproductive organs so long sought for in vain; and the accurate description and representation of which I consider to be the more justified, since the development of the spermatozoids also affords wholly peculiar and hitherto unknown relations.

The microscopic examination of the axillary capsules, almost always found upon the polypidoms of *Campanulariæ*, besides the ovi-capsules so well figured by Lovén, will occasionally disclose the existence of capsules, containing, not *ova* but distinct round globular bodies, of about the same size as the *ova*, though filled with a homogeneous granular substance, which when more minutely examined, after the rupture of the capsules, proves to be constituted of spermatozoids in very various stages of development.

These *male capsules*, as I shall term them in contradistinction to the female capsules containing *ova*, are indistinguishable from the latter by the naked eye either in size, form, or position. Like those they always spring from the angle, where a polype branches off from the main stem. Their length when

* German translation by Hornschuch, pp. 66, 67.

† Müller's Archiv., 1843, p. 174.

‡ Neuen Schweizerischen Denkschriften. Band viii.

full-grown is from one-third to one-half a line, their shape is that of an elongated vase with somewhat sinuous walls, the sinuosities corresponding to the globules contained in the interior.

Their peduncle commences with the same peculiar annular formation as is found in all *Campanulariæ* at the origin of each bud.

The separate spherical bodies by which this capsule is filled, to the naked eye appear of a whitish-yellow colour; they are larger and more opaque towards the wider, upper end of the capsule, and smaller and more transparent towards the peduncle. Each of them is surrounded by a thin membrane, and the whole together by a common transparent envelope. Into each globular mass is continued a process of the common nutritive substance entering the capsule (intestinal tube of Lovén), which is continued uninterruptedly throughout the whole polypidom; this process extends beyond the semidiameter of the globular body, and there terminates in a cæcal extremity. This nutritive substance of the contents of the capsule, having thus furnished a supply to each globule, expands beneath the horny cover of the capsule over its entire extremity, exactly as it is figured by Lovén in the female capsules. Within this nutritive substance may be perceived a lively motion of granules probably produced by vibratile cilia.

If one of these capsules, containing six or seven globules, be ruptured by compression under the covering glass, whilst in the microscope, the globules are seen to escape sometimes at the upper end, after rupture of the lid sometimes at the lower, if the capsule has been previously cut off from its peduncle, at the same time being emptied of their contents, so that it is easy now to recognize all the parts of them.

The uppermost globules contain fully-formed spermatozoids usually in active motion, with a minute round head scarcely 0·0001‴ in size, and a long, excessively delicate, appendage, distinctly perceptible only under very strong illumination, which vibrates actively backwards and forwards.

The motion of the spermatozoids cannot be perceived in the unopened globule, on account of the vast multitude assembled together—it is apparent only after the contents have been diluted with water.

The globules situated lower down in the capsule contain no perfectly-developed spermatozoids, but present them in various stages of development in the following order, proceeding from below to above.

The lowermost, smallest globules contain densely-crowded,

pale, nucleated, round cells, exactly like the spermatic germ-cells of other animals. In the globules placed higher up these cells are seen with a paler, almost inapparent *nucleus*, the outline of the cell has lost its uniform rotundity, and begins to elongate on one side into a short process. As the development proceeds, the *nucleus* disappears altogether, the cell is somewhat smaller and the process longer, and fine as a hair, exhibiting a very peculiar slow movement, not unlike that of the motile *cilium* of a *Euglena*, in consequence of which the entire cell acquires a quivering motion sometimes amounting to an inconsiderable change of place. This motion, however, is quite different from and slower than that of a mature spermatozoid. The cell is thrown from side to side, frequently appearing as if it was supported upon the process.

Other forms of development are commonly associated with the above in the same globule. Every cell has this flexible process, by the movement of which they are thrown from side to side; but besides this they have also a greater or less number of rigid, motionless, less delicate processes, varying in number from 1 to 5, and appearing to arise in succession, and by which these forms are rendered like the stellate cells of Kölliker, and which are a common stage of development of the spermatozoids in the Crustacea. But the latter have no motile appendage, and are always quite motionless.

I am not aware of any observation of movements at such an early stage of development of spermatozoids.

With respect to the successive formation of the individual processes, I have not been able to observe anything certain; but it appears to me probable that the *motile* process after a time becomes *immotile*, and that a new motile process commonly makes its appearance at the opposite point, which again passes into the motionless state, and so on.

It is only rarely that cells occurred without a motile process. The greatest number of rigid processes on a single cell, that fell under my observation, was four.

A necessary precaution to be taken, in order that the motion of the delicate process should be observed, is the avoiding too strong and too long-continued pressure upon the capsule with the view of rupturing it. The best way of proceeding is to provide that, besides the capsule, there should be a somewhat more resistant object—a portion of vegetable tissue or of the polypidom itself—and then, whilst looking through the microscope, to make gradual pressure upon the covering glass until the capsule is ruptured. If the pressure is now omitted, the glass usually rises again a little, affording the requisite space beneath it.

In what way the mature spermatozoids are produced from the above-described motile, stellate cells, I have found it impossible to observe. Notwithstanding that I have examined capsules of all sizes, I have never noticed any transition forms. The next highest globules always contained spermatozoids, differing from those in a state of complete maturity only in their having a somewhat larger body. In their movements they were precisely alike.

Whether a stellate cell divide into several spermatozoids or not, must be left undecided. In the Crustacea, we are also unacquainted with the metamorphoses of the stellate cells, not knowing even whether in any case they become motile spermatozoids. *Dromia Rumphii*, according to Kölliker, is the only Crustacean in which, together with stellate cells, bodies resembling filamentary spermatozoids are also found; but these were immotile.

The further change which takes place in the spermatic capsule for the evacuation of its contents is precisely like that which occurs in the female capsule for the development and expulsion of the embryos. When the spermatic capsule contains mature spermatozoids in the uppermost globules, the highest of those bodies breaks through the membrane by which the capsule is closed, and the envelope of the globule, which in the mean while had increased somewhat in thickness, represents a rounded *sacculus* placed upon a peduncle, and the surface of which opposite to the peduncle is furnished with a bundle of tentacular appendages. The peduncle encloses a continuation of the general nutritive substance, which at this time projects only for a very short distance into the spermatozoid-globule. The tentacles exhibit a slight degree of motility, inasmuch as they are capable of a slow extension and contraction; but they have no urticating organs, and are certainly wholly incompetent for the prehension of nutriment. Nor at first do they serve for the occlusion of an opening which is not formed till some time afterwards, when the very thin membrane in which the spermatozoids are still specially enclosed is ruptured. No movement of the entire envelope is ever observable.

Between the inner surface of this envelope and the mass of spermatozoids there is a space filled with active spermatozoids, when the membrane by which they are immediately enclosed is ruptured or bursts spontaneously. But the spermatozoids do not at once escape externally, as would necessarily be the case had an opening previously existed at the place where the tentacles are situated; and it is not until the outer envelope is also ruptured by stronger pressure that the spermatic elements are dispersed in the water.

When the spermatozoids have been evacuated in the natural way, the polype-like envelope contracts and ultimately disappears altogether, the next highest of the remaining globules in the meanwhile escaping in succession. Capsules occur with four or five polypoid envelopes attached externally, some of which, however, are always close upon disappearing.

Of the vessels, which Lovén has figured in the precisely similar *egg-tunics* seated upon the *ovi-capsules*, but which I have never been able to perceive in these tunics, no indications exist in the spermatic envelopes just described.

The male and female capsules are always placed upon different polypidoms, so that the *semen* has frequently a considerable distance to traverse in order to reach the *ova* to be impregnated. It may thence be concluded, that in sea-water the spermatozoids do not speedily lose their motility and capability of impregnation. I was still able to perceive the movements of the spermatozoids an hour after their liberation.

That an impregnation by the *semen* is indispensably requisite for the development of the *ova*, I have frequently satisfied myself, since it was only the ovi-capsules which had been associated with *male* polypidoms in a glass of water, that afforded embryos; whilst in those which had been kept apart, the *ova*, after entering the polypoid tunics from the ovicell, were always dissolved. The process of segmentation commenced in them, but soon remained stationary, and never reached the formation of an embryo. This fruitless process of segmentation taking place without impregnation was also noticed and figured by Lovén, but erroneously explained. He regarded it as a spontaneous division of an embryo for the purpose of multiplication, and believed that each separate cell would become an embryo.

Lister's drawing and description (Phil. Trans. 1834, Pl. X. Fig. *b* 4, p. 376), cited by Lovén on this point, and regarded by him as indicating the same thing as this futile division of the embryo, admit, as it appears to me, of a totally different explanation. The figure indisputably shows that Lister had seen the male capsules and the escape of the spermatozoids; but he had no notion of the meaning of what he thus observed.

With regard, lastly, to the polypoid envelope of the spermatic globules, it corresponds in all respects with the analogous tunic of the *ova* and embryos.

If the latter is to be regarded as the analogue of the free medusiform offspring of other *Campanulariæ* so also is the former—the tunic of the spermatozoids. I have already said that the decision of this question cannot be expected without

new and precise investigations of the *Campanulariæ* having a medusoid offspring, and therefore shall here avoid all useless discussion of it.

Memoir on the COLORATION *of the* CHINA SEA. By M. CAMILLE DARESTE. (From the Ann. des Sciences Naturelles, IV. Ser. Tome i. p. 81.)

WE learn from the observations of M. Ehrenberg, and more recently from those of MM. E. Dupont and Montagne, that the waters of the Red Sea are, at certain epochs, coloured red by the development, in prodigious quantities, of microscopical Algæ belonging to a species described by the former of these observers under the name of *Trichodesmium erythræum.*

These observations, which afford the best explanation of the term *Red Sea*, attributed by some ancient geographers to the aspect of the mountains bordering its shores when illuminated by the rays of the sun, and by others, since the celebrated Juan de Castro, to the transparency of its waters, which allows the coral reefs to be visible in their clear depths, have a still greater interest for naturalists; they are one of the most remarkable proofs of the immense development that microscopical organisms can attain, and of their importance in the physical history of the globe.

There is no such thing as an exceptional fact in science. The determination of a new fact, however strange it may at first appear to us, ought always to lead to the knowledge of other facts of the same nature which can be grouped round the preceding one, as different effects arising from a single cause.

Moreover, since these observations have been made, it has been thought that a great number of the accidental colorations of sea-water, so often described by navigators, might be thus explained. It might equally be expected that similar phenomena would be more frequently observed and described, from the moment that naturalists showed a scientific interest in them.

I owe to the kindness of M. Mollien, late Consul-general of France at Havanna, and one of the Frenchmen who have penetrated furthest into the interior of Africa, the opportunity of studying a new fact of this kind, which from the conditions under which it presented itself may one day open up an interesting geographical question.

M. Mollien observed last year that the China Sea was coloured yellow and red over a large extent, and that this coloration was not continuous but in patches separated by

transparent spaces. The red colour predominates in the true China Sea (*Nan-Hai*), which washes the shores of the south part of China, to the south of the island of Formosa; whilst the yellow colour predominates to the north of the island, and in the sea specially called the *Yellow Sea* (*Hoang-Hai*). The cause of this phenomenon is unknown. The English who trade in these latitudes attribute it to the spawn of fish—a popular explanation frequently given for all kinds of marine phenomena, and which had already been applied particularly to the coloration of the Red Sea.

M. Mollien collected a certain quantity of this coloured water, and, on his return to France, he kindly intrusted it to me for microscopical examination. He sent me at the same time the following note of the conditions under which the water had been obtained:—"The sea-water was drawn up, the 14th September last, in 10° N. lat. and 106° E. long. This water was not yellow, as in the canal of Formosa, but red."

The quantity of the water I examined was very small; it had deposited a sort of mud of a brown colour which I placed under the microscope. I recognised that this deposit was not formed, as one might at first have supposed, of earthy particles, but that it consisted entirely of an agglomeration of minute Algæ, almost microscopical and more or less decomposed.

These plants presented the appearance of little bundles, which cannot be better described than as resembling packets of cigars, and which resulted from the juxtaposition of a certain number of slender filaments, much longer than broad, of the same diameter throughout, and terminated by rounded extremities. These filaments were probably united by a mucous substance; but the state of these little plants did not allow me to ascertain this point. They were divided by a great number of transverse partitions into a series of cylindrical cells, the transverse diameter of which was nearly twice the longitudinal. These cells were slightly constricted in the middle, a sort of indication of their ulterior division. The membrane of the cells was colourless, but the colour might have disappeared in consequence of the incipient decomposition which the plants had undergone. In their interior a certain number of very fine granulations might be observed, which were slightly tinged with yellow. For the rest, the little plants were for the most part much changed: a great number of filaments were scattered in the fluid as well as a great many isolated cells resulting from the disintegration of other filaments. The study that I made of these little plants,

imperfect as it necessarily was, owing to my having only fragments more or less altered at my command, has not left a doubt as to their genuine nature. I found in them directly all the characters assigned to the genus *Trichodesmium* by MM. Ehrenberg and Montagne. The determination of the species was more difficult. These plants resembled greatly *Trichodesmium erythræum;* but I should not have been able to assure myself on this point, had not M. Montagne, whose authority on these subjects is so great, and who had kindly observed my Algæ under the microscope, changed my presumption into certainty.

From this fact, I could no longer doubt that the remarkable phenomenon of the microscopical vegetation in the Red Sea is also presented in the China Sea; and that true minute Algæ are the cause of the strange coloration which certain parts of that sea exhibit.

I wished to know if this fact had been already observed, and after many fruitless researches, I at last met with a very curious observation, which made me presume that these little plants had been already noticed, although the observers had mistaken their nature, and especially their origin. As this observation is very interesting in many respects, I shall venture to give it with some details. It is the chemical and microscopical examination of some sand which fell from a cloud at Shanghaï, made by Mr. Piddington, Curator of the Museum of Economic Geology of India. It is published in the *Journal of the Asiatic Society of Bengal* (1846).

This sand had been collected by Mr. Bellott, surgeon to H. M. S. "Wolf," and was transmitted by him to Dr. Macgowan, physician to the hospital at Ningpo, who in his turn forwarded it to the Asiatic Society of Bengal.

Mr. Bellott's letter is as follows:—

"*H. M. S. 'Wolf,' Shanghaï, March* 16, 1846.

"My dear Sir,

"I sent for the account of a shower of fine sand which fell here yesterday, the 15th. The wind was N. N. E., No. 1, rather fresh; then N. E., No. 2; then E. N. E., No. 3; and at last N. E.; and calm at sunset. A fog was observed, which was regarded as an ordinary fog; but the officers who were walking on the shore, remarked that their shoes and their trousers were covered with dust. I observed it myself in the afternoon. At 8 o'clock in the evening the dust was visible on the guns, the upper works, and other polished surfaces on the deck. I gathered as much of it as I could. In placing the dust upon the finger and raising it in the direction of the sun's rays, which on account of this phenomenon had only half their usual brightness, the particles which composed it were brilliant: although impalpable when held between the fingers and thumb, the dust caused a gritty sensation between the teeth. The dust passed over the vessel in light clouds, when the wind freshened; it was some-

thing like the fumes of tobacco, but without any bluish tint. About 2 P. M. I walked for two hours in the country: the whole atmosphere appeared laden with a light cloud of dust, tinged of a brownish colour; that was its aspect during the whole day. The setting sun had a diameter apparently less than in the winter evenings, and was of a sickly pale hue. At 10 o'clock P. M. I spread out two large papers to catch the sand: they remained spread out until past midnight; but although the sand fell and remained upon the guns none fell upon the paper. Was this the result of an electrical attraction or not? I cannot say. The stars in the Great Bear, although the firmament was without clouds, were visible only with difficulty at the zenith. The moon, three days past the full, was partially obscured, and threw a very feeble shadow upon my hand. At midnight the moon and the stars resumed their ordinary appearance, and at half-past one the quarter-master reported that the fog had ceased. The barometer fell from 30" to 29·88". The sand set the teeth on edge when one breathed it. The whole surface of this district is an alluvial clay, without flints or sand; the nearest sand, which is coarse and shelly, is 12 miles off. It is said that the merchant ship 'Denia' encountered this shower of sand at 30·5 miles from the land, in the direction of Leon-Tcheou, and that there was a kind of pounce-like dust upon the waves. As I have not seen her log I cannot certify this fact.

"Yours, &c.,
"J. BELLOTT."

Dr. Macgowan, in forwarding this letter from Ningpo to the Secretary of the Asiatic Society, adds the following detail to the narrative of Mr. Bellott:—

"I learn from Dr. Robertson, of the steamer 'Nemesis,' of the East India Company's service, stationed in this port, that on the day in question (15th March), he as well as several other officers had observed similar phenomena to those described by Dr. Bellott; the vegetation was covered with sand and also many of the ships, and the atmosphere was clouded. The wind was N. E. I was then absent at Chusan, where I did not perceive either sand or dust."

Besides the fact remarked by Mr. Piddington, it appears from Mr. Bellott's letter, and also from that of Dr. Macgowan, that the cloud of dust extended the same day from Ningpo, at the 30° of N. lat. to Shanghaï, at the $31\frac{1}{2}°$ in round numbers, which gives an extent of 90 miles; that it was accompanied by light winds from the N. N. E. and from the E. N. E. during seventeen hours, from 8 o'clock in the morning until an hour after midnight; that reckoning that the cloud travelled at the rate of $2\frac{1}{2}$ miles an hour (and that is the lowest rate that can be taken), the length of the cloud must be from $17 \times 21\frac{1}{2}$, that is to say 42 miles; and thus, in allowing for the little difference of longitude between Ningpo and Shanghaï, situated very near to one another, one to the N. W. and the other to the S. E., there remains an extent of 3,825 square miles for the cloud.

Mr. Piddington reports that having only had a grain and a half of sand in his possession he could not study it com-

pletely. "It is," he says, "an olive-green powder, the grains of which adhere to one another like the substances which remain on a filter, and mixed with filaments resembling hairs, of two kinds, some black, others white and thicker. Under the microscope, it is evidently a mass of very short filaments or fibres, transparent, white, black, and brown, with some spicules, reddish, sharp, and with grains of quartzose, transparent sand, adherent between them."

With some chemical tests the author recognised in this dust the existence of an alkaline salt of silex, and he obtained a small quantity of ammonia by its combustion. He came to the conclusion that it was formed of animal matter with very fine fibres, impregnated with an alkaline salt, probably carbonate of soda, and containing some grains of quartz. Afterwards observing this sand with a more powerful microscope, he recognised that these fibres were vegetable structures, and that they were *Confervæ.*

What could be the origin of this dust? Dr. Macgowan thought that it might be formed from volcanic ashes, and that it proceeded from the volcanoes of Japan. But the vegetable nature of this substance is manifestly opposed to this notion. Mr. Piddington also to account for the presence of microscopical plants in the sand even offers the following supposition. This sand and the *Confervæ* which it contains proceed from the interior of the continent, from the marshes and lakes which are so numerous in certain parts of China, from whence they are transported through the air by whirlwinds. It is true that, during all the duration of the phenomenon, the wind blew from the north-east. But this difficulty disappears when the existence of upper currents of the atmosphere is remembered, which blow in the intertropical regions in an opposite direction to the trade winds, that is to say, from west to east, and in the case in question from the land towards the sea.

I do not know what the physicists will think of this theory; but it is evident that the meteorological phenomenon observed by Mr. Bellott can be very easily explained by the observations which form the subject of the present memoir. If the Confervæ, or, to speak more exactly, if the Algæ of the genus *Trichodesmium* exist in such great abundance in the China Sea, it can readily be understood how these plants might be carried by the winds, and sustained in the air for a certain time under the form of clouds, and how they would fall during a wind from the north-east, without the existence of opposite directions of atmospheric currents being necessary; it is obvious also that these filaments might be impregnated

with sea-salt, so frequently drawn up, as is well known, by the evaporation of sea-water, and thus present the reaction of soda, without it being necessary to seek for the carbonate of soda in the deserts of Tartary, or the lakes in the interior of China, as Mr. Piddington suggests. If, further, the extreme frequency of fogs in the China Sea, and their density, be remembered, which caused the author of the history of Lord Macartney's embassy at the end of the last century to relate that in the Yellow Sea it was difficult to see from one end of the ship to the other, it is to be presumed that the phenomenon observed and described by Mr. Bellott is not unfrequent, and that there will very probably be opportunities of studying it anew and in a more complete manner.

It appears to me then, if not entirely demonstrated, at least very probable, that the *Trichodesmium*, which colours the waters of the China Sea to the south of the canal of Formosa, colours those also to the north of the same canal, and that this phenomenon is produced on a large scale. But it is possible that this phenomenon extends further still, and that it occupies in the sea a region limited to the south by the 15° of latitude, and to the north by the 38°, or in other words an extent of nearly 25°. It is quite natural to suppose that the name of Hoang-Hai (*Yellow Sea*), which the Chinese give to the sea that washes the northern shores of China and the western shore of the peninsula of Corea, is attributable to the existence of similar phenomena. All geographers attribute the colour of this sea to the existence of a yellow mud carried into its waters by the Yellow River (*Hoang-Ho*). Sir G. Staunton, who has given us the account of Lord Macartney's embassy, relates that, during the voyage of the English squadron through this sea, the vessels, although they had 6 fathoms water, carried away such a large quantity of mud that they left a trace of yellow brown in their wake for nearly half a mile. Now, that is precisely the appearance of the muddy deposit which was formed in the glass where I kept the water, the study of which forms the subject of these remarks.

All authors who have written on the geography of China, speak of the shallowness of the Yellow Sea, and of its shoals, formed in part of sand, and in part of the mud of which we are speaking, the deposition of which appears to be constantly going on. They cite, as an example of its rapid increase, the little island of Tsung-Ming, situated at the mouth of the Yang-tse-Kiang. This island is not marked upon the map of China, preserved at Venice, which was drawn from the rough draught of the celebrated traveller Marco Polo; whilst the island of Chusan, situated in its neighbourhood, is

to be found in it. It appears, then, probable that the island of Tsung-Ming, formed entirely of deposits of mud and sand, is of recent origin, and that it only existed as a shoal at the period when Marco Polo wrote the curious recital of his voyages. If, as might be thought, the mud of the Yellow Sea were almost entirely formed by the decomposition of our microscopical Algæ, we should have a new instance of geological formations due to microscopical organisms, the knowledge of which forms one of the most curious discoveries of our times, and one of those which will contribute the most to immortalize the name of M. Ehrenberg.

These are only conjectures, but they appear to me to possess a certain degree of probability. I hope that our increasing relations with China will give us before long the opportunity of clearing up all these questions.

One more question presents itself: one of the largest rivers in China and in the world, the Yellow River, or *Hoang-Ho*, which empties its waters into the Yellow Sea, and the overflowing of which has played such an important part in the history of China, since the earliest periods up to the present day, is itself of a yellow colour.

I have looked, in works treating on the geography of China, for some remarks on this coloration. The only important ones are to be met with in the following extract from the *Geography of Asia*, by Carl Ritter :—

"The evident meaning of the word *Hoang-Ho* is that of *Yellow River*. It is found already 200 years A. C.; for in the *Chou King*, this river is called *Uoang* (*yellow*), emblem of the earth; and *Hoang-Ti*, the God (*Ti*) upon the earth; or, in other words, the *Sovereign Master*, one of the titles of the emperor of China, as Lieutenant of the God of Heaven, *Shang-Ti*. In the upper part of its course, as far as the place where it leaves the wall of China, above Lautscheon, in the Kanson, the river has, like all alpine currents, perfectly transparent waters. When it washes the country of Ordos, it becomes muddy, of a thick yellow colour like the Tiber or the Maine: it is from that, that it takes its Chinese name *Hoang*, yellow or yellow-saffron (the missionaries call it *Saffron River*), as well as its Mongolian name *Karamoran* (from *kara*, dark, thick), under which it is described by Marco Polo. It sometimes happens, under extraordinary circumstances, that the water in the middle region of its course changes its nature. It is reported in the Annals, that in the year 1295, after a violent earthquake, the waters of the *Hoang-Ho*, which even at Lautcheon, usually begin to be thick, became during three days perfectly clear and transparent over an extent of 300 *li*, which was considered a happy prestige, and caused many congratulations to be sent to the court. But six months afterwards there was a great famine which cost the lives of many people."

However incomplete these documents are, they indicate the existence of a natural phenomenon. But what is the cause of it? Ought we to trace in it the record of microscopical vege-

tation? does there exist, as all geographers pretend, a relation between the coloration of the river and the sea? I can only place these questions before other naturalists who may have the opportunity of exploring these interesting districts.

Nouvelles Observations sur le developpement et la vie de Nematoides. Par MM. Ercolani et Louis Vella. (From the Comptes Rendus, July 3, 1854.)

1. The embryos of the ovaviparous Nematoid worms do not attain a complete development (that is to say are not furnished with reproductive organs) in the locality in which they are deposited by their mother, however favourable the conditions for their development may appear. The ova of the oviparous Nematoid worms, as well as the embryos of the ovaviparous, must quit the situation in which they have been deposited, and live in a state of liberty during a certain period, for their completion on re-entering the bodies of animals.

2. The ova of certain of the *Nematoidea* remain stationary in the intestinal *mucus* of the animals in which they were deposited by the parent; the phases of the development of these *ova* removed from the mucus ensue with great rapidity immediately they are placed in water.

3. The development of the *ova* of *Strongylus auricularis* (Zeder) has been obtained with tolerable facility in from two to five days, notwithstanding the complete state of putrefaction into which the bodies of the parent worms had fallen, and which had been collected at the same time.

4. The embryos thus produced have lived for twenty days in the water, but without growing or developing any reproductive organs.

5. Analogous Nematoid embryos are often presented in the little puddles of water in places where fowls are kept, and the excrements of domestic animals are collected.

6. Certain Infusoria, referred by Ehrenberg and other naturalists to the genera *Vibrio* and *Anguillula*, are nothing but nematoid worms in the embryonic condition; some, in fact, belonging without doubt to the genus *Oxyuris.*

Such, adds the Reporter (Prince Bonaparte), are the conclusions of an important memoir which the authors are hastening to communicate to the Academy of Sciences. Naturalists, he observes, will be struck by the analogy between the embryos above adverted to, and other embryos commonly found in stagnant waters, and which have been regarded as perfect animals. But how many of the putative *genera* of Infusoria, he asks, should be eliminated from science? Should the

whole class of *Infusoria* disappear or be split up into several? Such is the vast field opened to the meditations of Zoologists.

In the same number of the Comptes Rendus, M. de Quatrefages gives extracts of letters from M. V. Beneden, communicating the new and most important results at which he had arrived in prosecuting his researches on the *Cœnuri*.

M. Kuchenmeister had a dog which had been fed upon the *Cœnuri* of a sheep at the beginning of March, and which passed the tænioid "*Proglottis*," developed in its intestines from the *Cœnurus*.

The dog was killed on the 24th May, and M. Kuchenmeister sent some of the *Tæniæ* of the *Cœnurus* to Louvain, Copenhagen, and to Giessen. They arrived at Louvain on the 27th, contained in the white of egg, and were kept alive for eight days, the white of egg being renewed daily.

On the same day (27th) at 9 A.M. two lambs, about two months old, took each of them half a *Proglottis;* in the afternoon each took a whole *Proglottis*, and on the 3rd June one of the lambs swallowed another whole *Proglottis*.

On the 13th June, the first symptoms of 'staggers' showed themselves, and on the 15th one of the lambs was killed. The head was burning hot, the eyes red; the legs bent under the body, the animal ran with its head against the railing, and turned round and round in one direction.

The surface of the hemispheres of the brain above and below presented very irregular grooves, of which there were about a dozen. At the end of these tubes were found as many *Cœnuri*, almost all lodged in the cortical substance of the brain. Some were removed with the membranes. These *Cœnuri* were constituted of a simple vesicle of a milky white colour filled with fluid. At that stage they presented no heads (*Scolex*). They represented the hexacanth embryonic form (*Proscolex*), a little more developed than it is when it quits the *ovum*.

Yellowish-white corpuscles were subsequently found in the muscles and especially in the diaphragm, and which could be distinguished very well by the naked eye among the red muscular films; and which, as stated by M. Kuchenmeister, are nothing more than errant individuals, and incapable of further development.

M. Eschricht gives a similar account of his experiments with the *Proglottides* sent to Copenhagen, and some interesting observations on the mode of development of the *Scolex* form from the simple vesicle above noticed.

From Giessen, also, Leuckärt reports results of his experiments with the same *Proglottides*, in all respects identical with the above.

REVIEWS.

LECTURES ON HISTOLOGY, delivered at the Royal College of Surgeons of England in the Session 1851-52. By JOHN QUEKETT, Professor of Histology. Vol. II. Baillière. London.

IN pursuance of the plan laid down in his first volume, Professor Quekett has in this work presented us with another instalment of the histology of organic beings. The subject here taken up is the structure of the skeleton of plants and invertebrate animals. Although we hope Mr. Quekettt may be encouraged to proceed with the publication of his lectures, we think he has very judiciously selected his present subject as supplying a want of the physiologist and the microscopic inquirer. The fact is, at the present day, there is little to be added to our knowledge of the histology of the human body, and what we really want to complete our knowledge of the structure of organized beings, is more extended researches upon the lower animals. Our knowledge of vegetable structure, also, is much more extensive than it is of the lower animals. To all inquirers, then, in the field of comparative histology, this volume of Mr. Quekett's lectures will be found very acceptable. We cannot commend Mr. Quekett's volume as a comprehensive treatise upon all that is known with regard to the hard parts of plants and invertebrate animals; but, like that which renders all his other writings valuable, it bears the impress of original observation, and in all cases the reader may rely upon the accuracy of the author. Mr. Quekett nowhere commits himself to physiological inferences or speculations, leaving those who follow him to form their own opinions with regard to the functions and relations of the parts he describes.

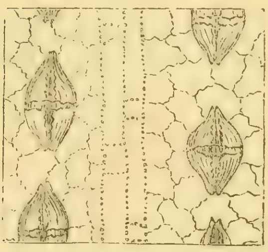
We shall now endeavour to give our readers an idea of the general contents of this volume, and are enabled, through the kindness of the publisher, to present specimens of the illustrations with which the work abounds. The first lecture is devoted to some general remarks on the nature of the skeleton, and to the skeleton of plants and sponges. The propriety of the application of the term skeleton to any part of a plant may, perhaps, be doubted. It is very certain that we have no organ, or set of organs, in plants, whose homologues we can point out in the vegetable kingdom. Every tissue in the

plant, in its time, becomes hard, and to no definite combination of cells can we apply the term skeleton. Nevertheless, the deposition of inorganic matters in the interior of the cells of plants, in a manner resembling the process of ossification in the animal kingdom, is a fact of great interest. Here, as in so many other instances of vegetable structure, we see the commencement of the processes which have great significance when carried on in the animal kingdom. The following observations on the siliceous deposits in the cells of plants will illustrate this remark.

"In plants, as I have before stated,* inorganic salts occur in a crystalline form, under the name of raphides; these, however abundant, may be regarded as accidental deposits, since it has been shown that they can be produced by artificial means. For the benefit of those who may not have been present on former occasions, I will give a few examples of the dermal siliceous skeleton of plants.

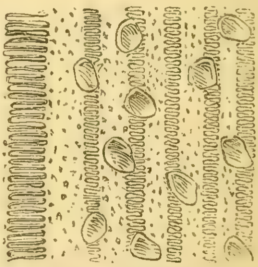
"The first specimen is a portion of the *Equisetum hyemale*, fig. 2, which has been boiled for a long time in nitric acid, and not only exhibits the cells of the cuticle, with their serrated edges, but also longitudinal rows of oval bodies, which are the stomata. Another good example is a portion of the husk of the *Wheat*, fig. 3, in which, in addition to the cells of the

Fig. 2.



A portion of the cuticle of *Equisetum hyemale*, after long boiling in nitric acid.

Fig. 3.



A portion of the husk of a grain of *Wheat*.

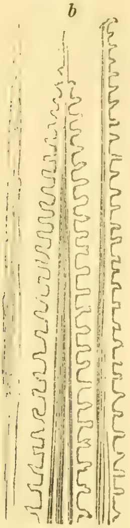
cuticle, the spiral vessels, recognized by the coiled-up fibre, also have a skeleton of silica. In the husk of the *Rice* the peculiar cells of the cuticle are seen, with bundles of woody fibre and vessels below them. The specimen is composed entirely of silica, and there may be noticed in one spot, where the cuticle has been torn, a series of elongated fusiform bodies, with serrated edges, fig. 4, which are all that remain of the woody fibres, proving that in this plant the silica is not confined to the cuticle. All the fibres, however, are not thus serrated; some, as represented at *b*, may be seen in bundles, which are both longer and thinner than the first mentioned, with perfectly smooth edges.

"On the upper surface of the leaf of a plant common in our gardens—the *Deutzia scabra*—there are numerous stellate hairs, which much resemble *Star-fishes* in miniature, fig. 5; these are covered with little

* Histological Lectures, Vol. I., p. 42.

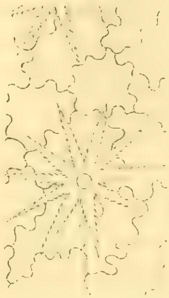
tubercles, each star being attached to the cuticle by its centre. If the cuticle be removed, and boiled in nitric acid, the stellate hairs may be as

Fig. 4.



Portions of woody fibres from the husk of the *Rice*.

Fig. 5.



Siliceous cuticle from the under surface of the leaf of *Deutzia scabra*.

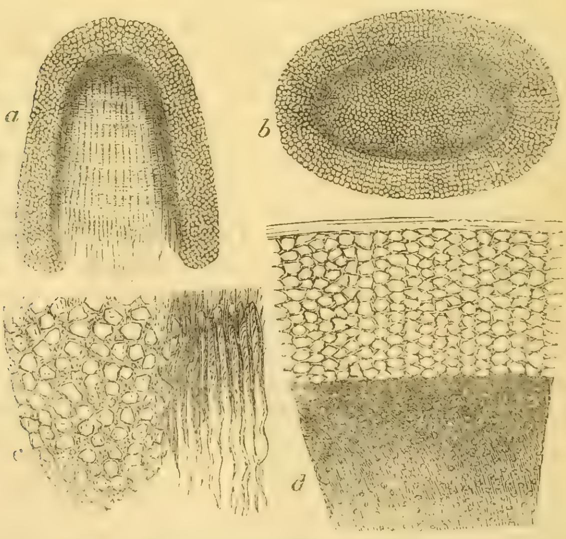
plainly seen as in the natural condition of the leaf; the crenated lines found in all parts of the object representing the cell-walls of the cuticle. This specimen will serve to show, which it does in a striking manner, that silica is not confined to the cells of the cuticle, but is equally abundant in the hairs and spines developed upon it."

The most definite forms assumed by the hard parts of plants, are undoubtedly those found in the *Diatomaceæ;* but as these have been so copiously illustrated in our pages, we may now pass them over. The Corallines are examples of plants having hard parts, closely resembling those to which we do not deny the name of skeleton in animals. Professor Quekett treats of these in his tenth lecture, with the hard parts of Zoophytes.

"As the Lithophytes occur in the greatest abundance upon coral reefs, where it would appear that the water is highly charged with carbonate of lime, and, as in former times, they were considered to be Zoophytes, I have thought proper to speak of their minute structure at this time, in order that you may have an opportunity of comparing it with that of the stony axis of the Corallidæ, and I must therefore beg of you to bear in mind that the comparison is of the greatest interest; for in both instances we have a great abundance of calcareous material which has been separated from the water by a vital process, that in the one case being effected by a vegetable, the other by an animal basis requiring the presence of

digestive sacs, or polypes, to maintain its integrity. If a vertical section be made of any Coralline, such for example as the *C. officinalis*, fig. 85, *a*, we shall find that, on examination with the lowest powers, it will exhibit two kinds of structure, both of which are essentially cellular—that on the exterior being composed of small cells of hexagonal figure, whilst in the interior they are more elongated, and generally of a brownish colour ; this is especially the case if a section should include a joint. In the fresh state the contents of the cells can be easily made out, and the central ones are not unfrequently full of greenish granules like Chlorophylle. The lime is not in the interior of the cells, but appears to be on the outside of the cell-walls, which are rendered opaque and thick in consequence. A portion of the vertical section, as seen under a power of 200 diameters, is represented at *c* : the dark parts on the outside of the cells there shown are the calcareous material ; the cells in the centre, as before noticed, are of an elongated figure, having little or no lime about them ; these also are exhibited at *c*, but the loose cells on the right side of the lower part of the figure, formed part of the articulation, and are entirely destitute of lime. A transverse section of one of the joints of the same Coralline, as shown at *b*, is wholly made up of cells, those on the margin being rather larger than the central ones ; both have an abundance of lime around them, as represented under a power of 200 diameters at *d*. The cells seen upon the upper portion of this figure having been deprived of their lime, are in consequence rendered very apparent. All the Corallines exhibit nearly the same structure, the outer portions being composed of cells of hexagonal figure, and the central of elongated ones ; the former are always coated with lime, whilst the latter are only partially so, and it is by the absence of the lime from these cells, at particular points, that the articulations are formed.

Fig. 85.



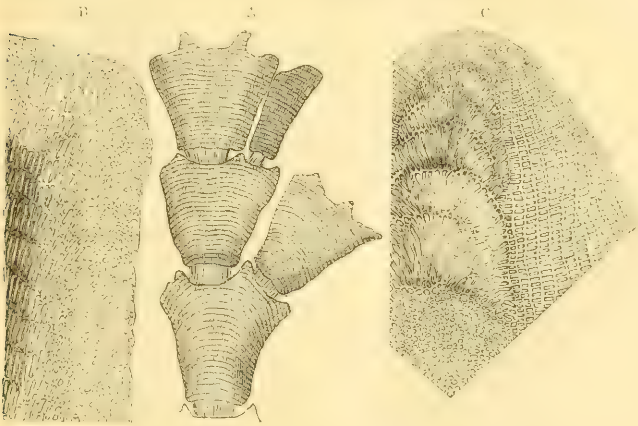
a, a vertical section of a joint of *Corallina officinalis* magnified 50 diameters. *b*, a transverse section of the same. *c*, a portion of the vertical section magnified 200 diameters. *d*, a portion of the transverse section magnified 200 diameters.

"A very striking specimen for exhibiting the structure of the articulations is *Corallina incrassata*; a vertical section of this plant is represented by A in fig. 86. The joints, as there shown, are composed of elongated cells, and from having no lime about them, are soft and flexible, and even of a green colour. A magnified portion of one of the joints is shown at B, and a transverse section at C, both are made up of cells, of which the central ones are much elongated. That the calcareous investment of the Lithophytes is not a mere precipitation from the water, as happens with many of the *Characeæ*, is, I think, very evident; for I have never yet seen any specimen of Coralline in which the part forming the articulation was coated over, nor has any section shown that the calcareous matter is ever present except as a coating to the cell-walls or the spaces between them. In the Nullipores, which have no joints, the cellular structure is of the same nature throughout; there are no elongated cells in the centre, as in the Corallines, consequently it would appear that the articulation is the result of a vital action in some of these cells, whereby they are deprived of the power of selecting a calcareous coating from the surrounding water, their energies being entirely devoted to the function of growth."

The lectures devoted to the Sponges contain a large number of illustrations of the peculiar forms assumed by the siliceous, calcareous, and cartilaginous matters of which their hard parts are composed. As illustrative of some of the forms assumed by spicula in sponge, we extract the following:—

"Other spicula are very peculiar, consisting of a central portion, or shaft, the extremities of which are furnished with two or three branches, each of these again subdividing into two or three still smaller branches. These spicula interlace with each other, and produce a sort of coarse network; they are generally found in small sponges, attached to masses of coral; two specimens of the largest kind are shown at *g g*, in fig. 14. In

Fig. 86.



A, a vertical section of *Corallina incrassata*, showing the joints. B, a portion of one of the joints. C, a transverse section of the same, both magnified 130 diameters.

the same sponge were others of smaller size, and with fewer branches, as represented by *d*, *e*, and *f*: to such spicula the term *branched* may be well applied. Another sponge contains spicula of the form I have termed *tuberculated*; they are of large size, and covered with rows of flattened tubercles, as shown at *c*, in fig. 14. The sponges to which they naturally

Fig. 14.

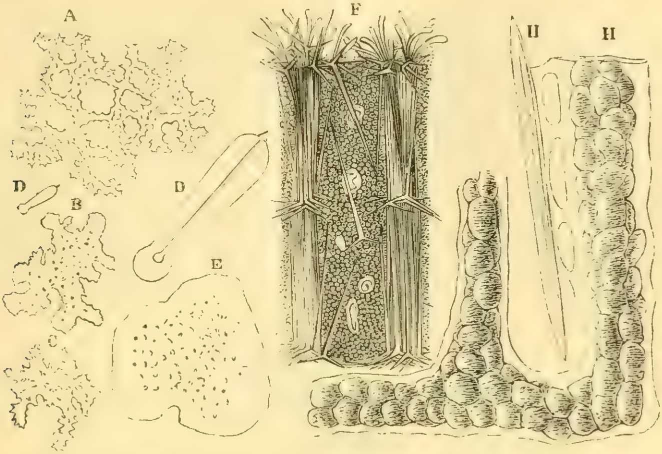
a, bi-curvate spiculum; *b*, curved spiculum; *c*, tuberculated spiculum; *d*, *e*, *f*, *g g*, branched spicula; *h*, bi-curvate anchorate spicula; *i*, stellate spicula; *k*, *l*, *m*, multi-radiate spicula.

belong I have never seen, but all my specimens were obtained from the root of an Alcyonium, *Alcyonium favosum*, from Sumatra, and were mixed with grains of sand and spicula of various kinds, from other sponges. A similar species, from a different part of the world, in the possession of a friend, when boiled in nitric acid yielded spicula of precisely the same kind; so much so, that when a specimen was shown me, I pronounced from whence it came.

"The siliceous remains of a small sponge, attached to the root of a Gorgonia, *Isis ochracea*, I found extremely rich in peculiar forms of spicula. The most striking was of a reticular figure, covered with minute spines, as shown at A, in fig. 15. It forcibly reminded me of the siliceous skeleton of the *Dictyochalix pumiceus*, before alluded to, and probably may be a portion of a siliceous sponge. Other spicula occur in the same specimen, the most remarkable of these are in the form of scales, as shown at B, C, E; they may be known by their flattened figure, and by having black dots in the centre. The edges of some of these spicula are smooth, but in most cases they are serrated. Another very singular form of spiculum is also found in the same sponge: it is of small size, and pin-shaped at one extremity, and at the other is rounded, but in the centre of the rotundity there is a short conical spine; two of these spicula are shown at D D. Spicula of the shape termed *curved* are occasionally met with in certain small sponges; one of these, of peculiar figure, is represented at *b*, in fig. 14. In another sponge from the South Seas, *bi-curvate* spicula, of the shape shown at *a*, are very common. Mr. Shadbolt, however, has detected some still more curious spicula than these last; they

are twice curved, like that shown at *a*, but each extremity is expanded, so as to resemble the fluke of an anchor; to such form, the term *bi-curvate*

Fig. 15.



A, portion of the skeleton of a siliceous sponge. B, C, E, flattened spicula. D D, pin-shaped spicula. F, tri-radiate spicula in *Grantia compressa*. H, granules of sand imbedded in horny fibre of *Dysidea*.

anchorate has been given; two of these spicula are represented at *h*. The sponge in which they occurred, like that of the preceding, was of small size, and brought from the South Seas."

From the skeletons of Sponges we pass to those of Diatomaceæ, Desmidieæ, Foraminifera, and Nummulites. The following observations on the structure of Oolitic rocks are not perhaps generally known.

"Before I leave this part of my subject, I must say a few words on the *Oolites*, which were formerly supposed to consist of the remains of organized beings of a globular figure, like the roe or eggs of fishes, but which are usually nothing more than grains of sand, each surrounded by a globular deposit of carbonate of lime and cemented together so as to form masses of limestone rock. The Oolites make up no inconsiderable part of the strata of this island; according to Ure,* they form a zone 30 miles broad in England, and are divided by geologists into the upper, middle, and lower Oolites. They furnish a most valuable material for architectural purposes; and are exceedingly rich in fossil remains, especially those of reptiles and corals.

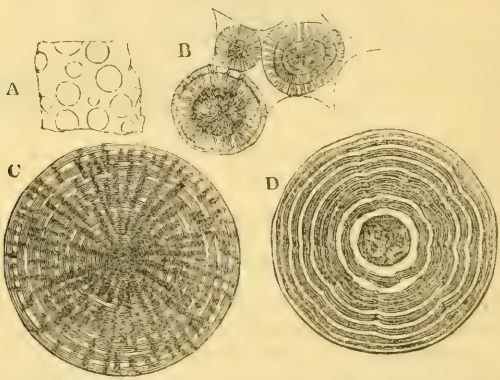
"The egg-like particles vary considerably in size, being in some cases almost invisible to the naked eye, whilst in others they are nearly as large as peas; this last form of Oolite has received the name of *Pisolite*, differing, however, from the true Oolites only in the relative size of the globular concretions. Bath stone, Portland stone, and the slate of Stonesfield, near Oxford, are all examples of Oolite. In fig. 52, A, is represented a portion of that form of Oolite termed Pisolite of its natural size; the

* Dict. of Arts and Manufactures, Art. Oolite.

granules are $\frac{1}{6}$th of an inch in diameter, one of them, shown in section at C, is magnified 12 diameters, and the concentric laminæ of which it is composed are well displayed.

"In Germany there is an Oolite in which the granules are nearly as large as they are in the Pisolite, but the concentric laminated arrangement, as shown at D, and the presence of a central nucleus, are more strongly marked; the rock supporting the Britannia bridge is a firm Oolite, in which the granules are remarkably small, those represented by B being magnified 40 diameters. The specimens just described are all very compact, the granules being firmly cemented together by the calcareous material forming the matrix: it sometimes happens, however, in oolitic districts, that the granules are separated from the matrix, and the soil will be seen to be in a great measure made up of them. This is especially the case in the neighbourhood of Bath; the soil of High Barrow Hill, I found to be so rich in oolitic granules, that when turned up by the plough, it appeared as if thickly sown with minute yellow seeds."

Fig. 52.



A, Portion of oolite termed *Roe-stone* or *Pisolite*. B, Granules from Britannia rock, magnified 40 diameters. C, Granule of *Pisolite* magnified 12 diameters. D, Granule of *Oolite* from Germany, magnified 20 diameters.

After the examination of the Nummulites, &c., we come to the great group of Zoophytes. These occupy several lectures, and contain many valuable observations. The structure of the skeleton of the Echinodermata is then gone into very carefully. From this part of the work we extract the following passage on the very curious bodies called Pedicellarieæ:—

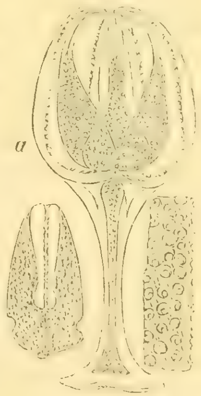
"We now come to other organs found upon the external surface of some of the Echinodermata, and these are the curious bodies termed *Pedicellariæ*. They were first described by Muller the Danish naturalist, and have been since investigated by Sars, a Norwegian clergyman. Muller believed them to be parasites, whilst Dr. Sharpey and others regard them as parts of the animal, which they undoubtedly are. On most Echini there are three kinds of Pedicellariæ; being considered as distinct animals, they have been termed *Pedicellaria tridens*, *Pedicellaria triphylla*, and *Pedicellaria globifera*, according to their form; but whatever this may be, each consists of a solid part, or skeleton, and a soft

transparent flesh. The skeleton, as shown in fig. 140, is composed of three calcareous jaws, having a sharp recurved tooth at the apex and an internal serrated edge, while the tissue surrounding the jaws is strengthened by minute bicurvate spicula; it is seated on a cylindrical stalk placed in the centre of the fleshy stem.

"All these parts, when highly magnified, present the characteristic structure of the shell of the animal; the soft tissue, on the contrary, is transparent, contractile, and, like that of the cirrhi, is capable of considerable elongation and flexion. While the Echinus is living, the Pedicellariæ are always in active movement from side to side, the jaws are continually opening and shutting, and if a small body be placed within them, it is held with tolerable force. They are attached to the soft fleshy covering of the shell by a dilated base, and are not confined to any particular part of the shell, but many may be seen on the thin membrane closing the oral aperture. The part which I have called the stalk is somewhat dilated at each extremity; its structure resembles that of a small spine, and it is stated by Sars that each stalk, like a spine, is articulated to a minute tubercle; but of the truth of this I have never yet been able to satisfy myself, as in all cases after their removal the soft stem has been found to completely invest the whole of the calcareous matter.

"If the Pedicellariæ be removed from the Echinus, they will continue in active movement for some time, and if one of them be touched with a needle or pin, those in the neighbourhood will all bend towards the one that has been irritated. In the Asteriadæ the Pedicellariæ are of a different form to those in the Echini—in the *Asterias rubens*, for example, in which they are very abundant, as shown at *a a*, in fig. 109, the calcareous jaws are like the two valves of a mussel, as represented at *b*, in fig. 140, two of the edges being serrated, whilst the other two, which are not closely approximated, have a semicircular notch, leaving an opening between them when in apposition, and the stem is short and flexible, but not provided with a calcareous axis as in the Echinidæ. When magnified 130 diameters, as shown at *c*, the characteristic reticulated structure is exhibited. Mounted specimens, taken from the outer surface of the shell of *Echinus miliaris*, as represented at *a*, in fig. 140, show very distinctly the three jaws and the axis or stalk, but being in a state of contraction, the soft parts appear very short and puckered up, so that a species of neck is formed between the jaws and the axis; this, however, is not the case in living specimens. All the parts composing the skeleton of the Pedicellariæ exhibit the characteristic reticulated structure of the Echinodermata. The jaws are thin, flattened below, sharp above, and bent nearly at right angles, so as to form a tooth; the axis is about $\frac{1}{6}$th of an inch in length and dilated at both extremities, and in shape and structure is very like the spine of an Echinus. On either side of the jaws may be seen a row of small bicurvate spicula, somewhat resembling those in the disc of the cirrhi of the Echinidæ, but differing from them, as represented at *d*, in Plate XIV., fig. 19, of the first volume

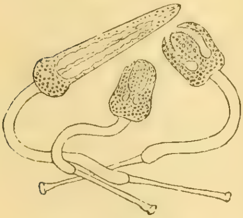
Fig. 140.



a, *Pedicellaria* of *Echinus miliaris*. *b*, skeleton of one of the *Pedicellariæ* of *Asteria rubens*. *c*, portion of the skeleton of the same magnified 130 diameters.

of the 'Histological Catalogue,' in having more than one hooked process extending outwards from the point where the curved portion commences. Under a power of 40 diameters, as shown at *a*, in fig. 109, numerous Pedicellariæ are distinctly visible on the upper dermal surface of *Asterias rubens*, even after having been dried; but as the soft fleshy stalk is very short and has no calcareous axis, little can be seen except the jaws. Pedicellariæ also exist in the *Spatangi*, but they are not so evident as in the Echini; the principal varieties found in *S. purpureus*, according to Forbes, are represented in fig. 141.

Fig. 141.



Pedicellariæ of *Spatangus purpureus*

"The Pedicellariæ then, without doubt, belong to the animal on which they are found; they are not parasites, but it is difficult to determine their true office; they are probably useful in keeping the shell free from all intruders of a parasitic nature, and may be supposed to perform an analogous function to that of the so-called 'Bird's-head processes' of the *Bryozoa*."

The Mollusca and Articulata are treated of after the Echinodermata. The shells of the principal families of the Mollusca are examined in detail, and many new points in their structure described and illustrated. The Articulata are not treated so much in detail. In these concluding lectures we had marked some passages which we should have liked to have transferred to our pages. We have, however, given sufficient for our readers to form an estimate of the work, which we are sure will be of such a kind as to lead them to feel that it is one of great value to the microscopical student. The illustrations are very copious, and every one will be able to form an opinion of their excellence from those we have given above.

NOTES AND CORRESPONDENCE.

On the Aperture of Object-glasses.—It appears to me that your correspondents on the subject of the aperture of object-glasses for microscopes, and the methods of measuring the same, have left the simple means of ascertaining the angle of aperture, and taken up with such complex methods, that they have been led into very considerable errors; and hence the erroneous results, in my opinion, of Professor Robinson and Mr. Wenham, particularly with regard to objects mounted in balsam. My method of measuring the angle of aperture is, to use the object-glass of the microscope as the objective of a diminishing telescope, making use of a single lens of an inch and a half focus for the eye-piece of the telescope, and then fixing this little telescope on a divided circle with the focus of the objective over the centre of the circle, or else by placing two candles so that each of them may be at the extreme edge of the field of view of the telescope. In the first case, the angle of aperture is accurately measured by the circle, when the image of the flame of a distant lamp or candle is made to traverse the field of view of the telescope; in the second case, lines drawn from the objective to the two candles form the angle of aperture, which may be easily measured by a common protractor. Now, by taking either of those methods, and measuring the angle of aperture with nothing intervening, with a slider containing an object mounted dry, or one with an object mounted in balsam; the results were (as they ought to be from the laws of light) in all cases exactly the same. Had Professor Robinson's and Mr. Wenham's results, with regard to balsam-mounted objects, been correct, the two candles placed at the extreme edge of the field of view, in a lens of 150° of aperture, would have required to have been brought more than four times as near together,* when the slider with the balsam-mounted object was interposed, as when it was not; but the candles did not require moving, but remained at the edge of the field, whether the slider was there or absent. Again, two sliders were taken of exactly the same thickness, the one containing objects mounted dry, the other objects mounted in balsam; one of these being placed on the stage of the microscope, was illuminated with such

* The proportion of the tangents of 75° and 40°, or half the angle of aperture.

extreme oblique light, that only one-half of the field of view of the microscope was illuminated; the line of demarcation between the illuminated part of the field and the black-ground part, passing directly through the centre of the field, and this division of the field remained constant when no slider was on the stage, when the one with the objects mounted dry was placed there, and when the one with the balsam-mounted objects was used. Had the angle of aperture been at all altered or lessened, by the interposition of the sliders, it must instantly have become visible by the change of illumination in the field of view of the microscope.

When I first read the account of the results obtained by Professor Robinson and Mr. Wenham, it struck me forcibly that they must have committed some great error; for, in experiments with the fine linear objects, I had never been able to see the markings on the *N. rhomboides* with an angle of less than 120°, when it was mounted dry: now, if it cannot be seen with less than 120° when mounted dry, it would be impossible with any angle to see the markings on it when mounted in balsam; as an angle of 150° (according to the results given in your Journal) would be reduced to less than 80° when employed to examine an object in balsam; but in opposition to this, I always consider that with my 1-12th of 150° of aperture, I can see the markings on *N. rhomboides* better in those specimens which I have in balsam, than in those which are mounted dry; and Mr. Wenham himself stated to me that he had never seen the markings on *N. rhomboides* so well as he saw them on one of my dry specimens, and yet at least they are equally as distinct on those which I have in balsam. I should advise both Professor Robinson and Mr. Wenham to go over their experiments once more, and I think they will be able to determine how they have fallen into error.—J. D. Sollitt, *Grammar-School, Hull.*

Illumination of Microscopic Objects.—I beg permission to insert in the next number of the 'Quarterly Journal of Microscopical Science' a short comment on Mr. Rainey's remarks on my paper on microscopic illumination. I have no desire to raise a controversy that must in the end be perfectly useless, but as Mr. Rainey misquotes my sentences, and implies that I am "dogmatical," a few words in reply may perhaps be allowed, with the understanding that I feel all due deference and respect for Mr. Rainey's long experience as a microscopical observer.

In the first place, where can be the "ambiguity and com-

plexity" of my assertion, that light cannot be totally reflected either externally or internally from refracting bodies with parallel sides, when this is a well-known and simple optical fact, yet Mr. Rainey again states that the *total reflection* he alludes to " is supposed to be from one surface only, namely, from that on which the rays are incident?"

I have stated that the undulatory theory of light has *very little or nothing* to do with the illumination of microscopic objects. Mr. Rainey has cleverly turned these four short words, and assumed that I, with great presumption, have ventured to deny the undulatory theory being a correct one, and then proceeds to argue and defend the case as if I had really done so. My meaning (which will be easily understood by referring to my paper) was simply this.—When we view a house, a tree, or a distant landscape, I think that it will be admitted that there is no occasion to refer to the undulatory theory to account for their visibility. The same reasoning may also be applied to objects of minute size, as the point of a needle, fibres of a piece of textile fabric. All these conditions are still in existence when a magnifying lens is used, which in effect merely serves to shorten the focus of the eye. I cannot see the utility of attempting to endow minute objects with exclusive properties *when under the microscope;* their illumination and visibility are simply a question of quality and direction of light, the same as in all ordinary cases.

Mr. Rainey will, I trust, pardon me for stating that I have not " invented any new theories" to explain the action of my parabolic condenser, for, to use his own words, " these facts allow of an easy and obvious explanation upon long-established principles." The whole of this implied theory rests upon my making use of the term " radiated light." If Mr. Rainey will distinctly contradict the fact, that an illuminated atom does in reality radiate light in all directions, I shall be better able to answer the question.

I must remonstrate against Mr. Rainey's assertion that I myself " evince great dissatisfaction with the term radiated light." This refers to a note at the end of my paper, stating that I had adopted the term because it was descriptive and convenient, though *perhaps not philosophically correct.* Mr. Rainey's application of this remark only serves to show me that this is an admission that I ought not to have made.—F. H. WENHAM.

New Achromatic Condenser.—Having invented a new kind of achromatic condenser of general utility, for all kinds of illumination, and finding it much superior to anything of the

kind I have yet seen, I feel desirous that others should avail themselves of the advantages attendant on its application to the microscope.

This condenser consists of two achromatic lenses, one of four and the other of two inches focus. The four-inch lens has an aperture of an inch and a quarter, the two-inch lens an aperture of three-quarters of an inch; they are placed at one inch and three quarters asunder, and the compound focus is an inch beyond the smaller lens. This condenser is placed below the stage of the microscope, but contrived to revolve in the arc of a circle, so as to vary its position from perfectly direct light, to the greatest obliquity of position that may be required for illuminating the most delicate linen objects. Its distance from the stage when used with the higher powers being such, that in every position a perfectly well-defined image, either of the flame of the lamp, or the bars of the distant window, is depicted on the slider holding the object. The two achromatic object-glasses, which form the condenser, require to be accurately made, and when so formed the light from it is most intense and of the purest kind, at the same time producing a degree of definition superior to that of any other method of illumination that I have seen: in addition to this, the illumination is equally perfect for the most oblique light; so much so, that when the axis of the condenser is inclined to the axis of the microscope, for the most extreme angle required with lenses of 150° of aperture, there does not appear any diminution either of light or definition.

For microscopes furnished with this condenser no concave mirror would be required; and for illumination with the low powers it is only necessary to slide the condenser further from the object, so as to illuminate it by a broader part of the pencil of light.

The light may be either admitted directly through the condenser, or reflected through it by means of a plain mirror. By the use of this condenser I have resolved many of the delicate test-objects with a 1-4th of an inch lens of 95° of aperture, that would be found under ordinary illuminations very difficult to resolve with a 1-8th object-glass and 130° of aperture.

The two lenses used in this condenser are constructed on the same principle as all achromatic combinations for the microscope, their plain sides being turned towards the object, and the wider lens of course placed next the light. A good workman will easily contrive an elegant method of fixing the condenser to the microscope, and it may be adapted so that the axis of the condenser may be brought to the required angle

with the axis of the microscope, by rack-and-pinion movement, as well as varied in its distance from the stage by the same kind of motion. It may be further observed that when the angle, which the axis of the condenser makes with the axis of the microscope, is greater than half the angle of aperture of the object-glass, the black-ground illumination is produced in the most perfect manner. Provided this condenser be attached to the stage of the microscope by a circular arc divided into degrees, the angle of aperture of the object-glass under all conditions can be accurately ascertained, for the limit of aperture will be when the illuminated field is just passing into the black-ground illumination.—J. D. SOLLITT, *Grammar-School, Hull.*

Microscopical Examination of Deep Soundings from the Atlantic Ocean.—The soundings examined were as follows:—

1080 fathoms,	Latitude	42° 04′ North,	Longitude	29° 00′ West,	July 25, 1853.
1360	,,	,,	44° 41′ ,,	,,	24° 35′ ,,	,, 18 ,,
1580	,,	,,	49° 56′ 30″	,,	13° 30′ 45″	Aug. 22 ,,
1800	,,	,,	47° 38′ ,,	,,	09° 08′ ,,	No date.
2000	,,	,,	54° 17′ ,,	,,	22° 33′ ,,	,,

As these soundings are believed to be the deepest ever submitted to microscopic examination, and were obtained at localities far remote from those previously noticed, they were studied very carefully, and the following are the facts ascertained:—

1. None of these soundings contain a particle of gravel, sand, or other recognizable unorganized mineral matter.

2. They all agree in being almost entirely made up of the calcareous shells of minute, or microscopic Foraminiferæ (*Polythalamia*, Ehr.), among which the species of *Globigerina* greatly predominate in all the specimens, while *Orbulina universa*, D'Orb., is in immense numbers in some of the soundings, and particularly abundant in that from 1,800 fathoms.

3. They all contain a few specimens of non-parasitic or pelagic Diatoms, among which *Coscinodiscus lineatus*, *C. excentricus*, and *C. radiatus* of Ehrenberg, are much the most abundant.

4. They all contain a few siliceous skeletons of Polycistineæ, among which are several species of *Haliomma*, *Lithocampe*, &c.

5. They all contain spicules of sponges, and a few specimens of *Dictyocha fibula*, Ehr.

6. The above-mentioned organic bodies constitute almost the entire mass of soundings, being mingled only with a fine calcareous mud derived from the disintegration of the shells.

7. These soundings contain no species of Foraminifera belonging to the group of *Agathistegues* (*Plicatilia*, Ehr.), a group which appears to be confined to shallow waters, and which in the fossil state first appears in the tertiary, where it abounds.

8. These soundings agree with the deep soundings off the coast of the United States, in the presence and predominance of species of the genus *Globigerina*, and in the presence of the cosmopolite species of the *Orbulina universa*, D'Orb., but they contain no traces of the *Marginulina Bacheii*, B., *Textilaria Atlantica*, B., and other species characteristic of the soundings of the western Atlantic.

9. Examined by chromatic polarized light, the foraminiferous shells in these soundings showed beautiful coloured crosses in their cells, and the mud accompanying them also became coloured, showing that it is not an amorphous chemical precipitate. It in fact can be traced, through fragments of various sizes, to the perfect shells of the Foraminiferæ.

10. In the vast amount of pelagic Foraminiferæ, and in the entire absence of sand, these soundings strikingly resemble the chalk of England, as well as the calcareous marls of the Upper Missouri, and this would seem to indicate that these also were deep-sea deposits. The cretaceous deposits of New Jersey present no resemblance to these soundings, and are doubtless littoral, as stated by Prof. H. D. Rogers (Proc. Bost. Soc. Nat. Hist. 1853, p. 297).*

11. The examination of a sounding, 175 fathoms in depth, made in latitude 42° 43′ 30″ N., longitude 50° 05′ 45″ W. (near Bank of Newfoundland), by Lieut. Berryman, gave results singularly different from those above stated. It proved to be made up of quartzose sand, with a few particles of hornblende, and not a trace of any organic form could be detected in it. This exceptional result is important, as it proves that the distribution of the organic forms depends on something else beside the depth of the water.

12. Connecting the results above mentioned with those furnished by the soundings made in the western portions of the Atlantic, it appears that, with the one exception above mentioned, the bottom of the North Atlantic Ocean, as far as examined, from the depth of about 60 fathoms, to that of more than two miles (2,000 fathoms), is literally nothing but a mass of miscroscopic shells.

13. The examination of a large number of specimens of ocean water taken at different depths by Lieut. Berryman, at situations in close proximity to the places where the sound-

* American Journal of Science and Arts.

ings were made, shows that even in the summer months, when animal life is most abundant, neither the surface water, nor that of any depth collected, contained a trace of any *hard*-shelled animalcules. The animals present, some of which are even now alive in the bottles, are all of a soft, perishable nature, leaving on their decay only a light flocculent matter, while the Foraminiferæ and Diatoms would have left their hard shells if they had been present.

As the species whose shells now compose the bottom of the Atlantic Ocean have not been found living in the surface waters, nor in shallow water along the shore, the question arises, Do they live on the bottom at the immense depths where they are found, or are they borne by submarine currents from their real habitat? Has the Gulf-stream any connection by means of its temperature or its current with their distribution? The determination of these and other important questions connected with this subject requires many additional observations to be made. It is hoped that the results already obtained will induce scientific commanders and travellers to spare no pains in collecting deep-sea soundings. If such materials are sent either to Lieut. Maury, U. S. Observatory, or to myself at West Point, N. Y., they will be thankfully received and carefully studied.—J. W. Bailey.

On some new Localities of Fossil Diatomaceæ.—Some interesting specimens of fossil Diatomaceæ from California and Oregon having come into my possession, I am induced to publish the following brief notices of them, in hopes to direct the attention of travellers in those regions to those remarkable deposits, and thus acquire more information concerning their position and extent.

1. The first specimen of fossil Diatomaceæ from California, I found among specimens of minerals collected two or three years ago in California by Washington Chilton, Esq., of New York. It was from *Suisun Bay*, 25 to 30 miles above St. Francisco, where Mr. Chilton says a large bed of similar material exists. It consists of a light white clay-like substance made up entirely of fossil *marine* Diatoms, many species of which are identical with species occurring fossil in the tertiary diatomaceous deposits of Virginia and Maryland, while a number of the species found in these latter deposits do not occur in the California beds.

2. In a box of minerals, collected in Oregon and California by Lieut. Robert Williamson, of the U. S. Topographical Engineers, I found four specimens of fossil diatomaceous earth, evidently from different localities, although unfortu-

nately the precise locality is mentioned for but two of the specimens. I will designate them as specimens A, B, C, and D.

Specimen A.—This is a very light white substance, made up of the siliceous shells of *fluviatile* Diatoms. The predominant species are a small *Gallionella* and a *Discoplea*, mingled with a few species of *Epithemia*, *Cocconema*, *Gomphonema*, and *Spongiolites*. This specimen was without a label, but is believed to be the specimen referred to in the following extract from a letter received from Lieut. Williamson :—" You will find some of the light white clay from *Pit River*, which I spoke of to you." This is, I believe, the same substance which has given rise to the newspaper accounts of cliffs in California composed of carbonate of magnesia.

Specimen B.—This is a light white chalky mass, whose locality is not given. It consists of fluviatile species, among which various species of *Biblarium* are quite abundant. The species of this genus have been found living in Siberia, and fossil in Oregon. Lieut. Williamson's specimen resembles the Oregon mass found by the U. S. Exploring Expedition under Captain Wilkes, but presents a different group of forms and therefore must be from a different locality.

Specimen C.—This is also a chalk-like mass, whose precise locality is not marked. It is composed chiefly of a minute species of *Gallionella*, mingled with sieve-like discs, which at first would be referred to the marine genus *Coscinodiscus ;* but the entire absence of all other marine forms, and the presence of several decidedly fluviatile species, make me believe that the deposit is a fresh-water one, and careful examination of these discs show that they are more nearly allied to the fresh-water genus *Stephanodiscus* than to the marine *Coscinodiscus.*

Specimen D.—Is an ash-coloured earth, marked as from near the Boiling Spring, Pit River. It is chiefly remarkable for containing a great number of *Phytolitharia*, or remains of the siliceous portions of plants, mingled however with numerous minute fluviatile Diatoms.

It is hoped that travellers in California and Oregon will keep a look-out for specimens of light white clay-like substances, and *carefully marking the locality at the time of collection*, send them to me for microscopic examination. Even a minute portion sent by mail will be very acceptable.—J. W. Bailey.—*American Journal of Sciences.*

Powell and Lealand's New Condenser.—In the last October number of the 'Microscopical Journal,' I observed a notice of Powell and Lealand's new condenser, by Dr. Inman of Liverpool, in which he mentions his having demonstrated the

markings on the *Ceratoneis fasciolata* (*Pleurosigma fasciola*), by means of using a 1-8th-inch object-glass, which power I presume he considered necessary for that purpose. I have now the pleasure of stating that with the same kind of condenser, but with one of Powell's recently-made 1-4th-inch objectives, I have brought out the markings of this species in the most satisfactory manner; also *with the same power* the markings, rather difficult of detection, of the *Pleurosigma delicatulum*, *intermedium*, *nubicula* and *Æstuarii*, and of *Nitzschia sigmoidea*, using, however, in place of the achromater, Shadbolt's Annular Condenser, with the light direct from the lamp—a method of illumination which seems to be especially adapted to the demonstration of delicate test objects. The same result has been obtained, but I think in a more perfect manner, by means of the prism furnished by Powell and Lealand, which should be so adjusted for this purpose as to give the object illuminated on a perfectly black field.

The above facts may be interesting to some of your readers, should you deem them worthy of insertion in the next number of your Journal.—E. BLEAKLEY, M.D., *Norwich.*

New Species of Diatomaceæ.—The species of Diatomaceæ here described as new, together with others, were detected either as parasites upon Algæ, or entangled in mud adhering to shells, Algæ, &c., brought home by the Exploring Expedition under the command of Capt. Wilkes, U.S.N.

1. *Amphitetras favosa*, Harvey et Bailey. Loricis tabularibus; lateribus vix concavis, primario; secundario quadrangulo, angulis fere rectis vix productis, superfice cellulis magnis hexagonis tessellata. *Hab.* Mindanao.

2. *Amphitetras Wilkesii*, H. et B.; loricis prismatico-tabularibus, lateribus concavis, primario longitudinaliter striato-punctato medio transversim zonato; secundario quadrangulo, angulis productis rotundatis, superficie cellulis minutis in lineas simplices furcatasque dispositis notata, prominentiis jugalibus punctulatis. *Hab.* Puget's Sound.

3. *Aulacodiscus Oreganus*, H. et B.; loricâ prominentiis redecim intramarginalibus instructa, a quibus tot radii fere ad umbonem procurrent; superficie præter umbonem glaberrimum, minute punctatâ iridescente. *Hab.* Puget's Sound.

4. *Campylodiscus Kützingii*, H. et B.; sellæformis, late marginata, sulcis subquinquaginta transversis continuis curvatis impressa. *Hab.* Mindanao.

5. *Cocconeis parmula*, H. et B.; late elliptica, linea media longitudinali notatâ, utroque latere costis (vel sulcis) trans-

versis magnis 10-12 irregularibus impressa; superficie transversim striato-granulata. *Hab.* Tahiti.

6. *Cocconeis rhombifera*, H. et B.; late elliptica vel suborbicularis, lineâ mediâ oblique-longitudinali sigmoideâ areolam glabratam percurrente quæ apice et basi attenuata est, et versus umbonem in rhombi formam ampliata; superficie decussatim et transversim punctatâ. *Hab.* Puget's Sound.

7. *Cocconeis sulcata*, H. et B.; late elliptica vel suborbicularis, transversim sulcata, sulcis 30-40 arcuatis. *Hab.* Puget's Sound.

8. *Hyalosira punctata*, H. et B.; loricis magnis in catenas longas co-ordinatis rectangulis subquadratis transversim interruptè vittatis; vittis medio loricæ alternantibus granulatis, alternis serie punctarum insignium ornatis. *Hab.* Tahiti.

9. *Isthmia minima*, H. et B.; zona transversali subtilissime decussatim punctata, lateribus (secundariis) cellulis magnis granulata. *Hab.* Rio Janeiro and Sooloo Sea.

10. *Triceratium concavum*, H. et B.; loricâ lateribus valde concavis angulis rotundatis, superficie triquetrâ cellulis minutis in lineas radiantes simplices furcatasque co-ordinatis notata; prominentiis jugalibus punctulatis. *Hab.* Tahiti.

11. *Triceratium gibbosum*, H. et. B.; parvum, fere inflato-globosum, lateribus valde convexis, angulis prominentibus, superficie ut in T. concavum notata. *Hab.* Tahiti.

12. *Triceratium orientale*, H. et B.; magnum; lateribus convexis angulis productis obtusis, superficie triquetrâ cellulis magnis hexagonis favosa. *Hab.* Mindanao.

13. *Triceratium Wilkesii*, H. et B.; loricâ lateribus convexiusculis angulis rotundatis, superficie ut in *T. concavum* notatâ. *Hab.* Puget's Sound.

APPENDIX.

14. *Lagena Williamsoni*, H. et B.; testa bicellulosa, cellulis diversis, inferiore ellipsoidea longitudinaliter costata in isthmum infundibuliformem attenuata, et ad cellulam superiorem glabram semi-lagenæformem (vel inverse infundibuliformem) ferruminata; collo breviusculo recto, ore subampliato. *Hab.* Mindanao.—Professor W. H. HARVEY and Professor J. W. BAILEY, *in Proceedings of Academy of Nat. Sciences, Phil.* Oct., 1853.

PROCEEDINGS OF SOCIETIES.

Geological Society.

On the Microscopical Structure of Freshwater Marls and Limestones. By H. Clifton Sorbey, F.G.S.

The author first described the general conclusions he had arrived at with respect to the condition of the mineral portion of calcareous organisms, which he considered is first deposited in the form of crystalline granules of variable size, that afterwards undergo more or less of crystalline coalescence. In some cases this scarcely occurs at all; but in others it does to a very considerable extent during the life of the organism, and this produces a great difference in the character of the particles into which it is resolved by decay. The falling to powder that then takes place is the result of the oxidization and removal of the organic portion, and, if no crystalline coalescence had occurred, the shell or other body might be resolved into the very minute, ultimate, crystalline granules; whereas, if much coalescence had taken place, it would break up into much larger ones, showing in many instances its minute organic structure.

The particular forms of the particles into which the Limnæans and Paludinæ, found so plentifully in many fresh-water marls, are resolved by decay, were then described and shown to present such definite characters as to render it easy to distinguish them with certainty from most others at all likely to occur in them. Soft, loose marls can of course be investigated by mixing the particles in water; but thin sections of harder limestones must be prepared, and the facts which may be learned from them are in many respects very superior; and from them the relative proportion of the various constituents may be determined with great accuracy, by carefully drawing their outline on strong even paper with a camera lucida, and afterwards cutting out the several portions and weighing them. This method the author terms "physical analysis." To fully describe all the necessary particulars would occupy too much space for this abstract; but, by attending to them, very great accuracy may be attained, and the true physical constitution of the specimen stated in a manner quite different from what could be ascertained by chemical analysis, which, for the purpose of these inquiries, is often greatly inferior, though often most valuable in addition.

Proceeding to the application of these methods of research to particular cases, some white marly deposits found in some of the filled-up lakes of Holderness were described, and shown to be composed of such particles as result from the decay of *Bithinia tentaculata*, mixed with a small but variable proportion of such as are derived from decayed Limnæans. In confirmation of this it may be stated, that though no entire shells are found in them, yet

numerous opercula of the *Bithinia* occur, which therefore appear to have been less prone to decay than the shells themselves. Other similar marls of post-tertiary age were also described, and shown to have resulted from the decay of similar shells in variable proportion.

The soft marly portions of the Isle of Wight tertiary fresh-water limestone were stated to be of precisely the same nature as the above, being composed of such particles as result from the decay of Limnæans, in which term are included *Limnæus* and *Planorbis*. The examination of thin sections of the harder varieties of the same limestone also shows that they were derived from the same source, mixed with a variable, sometimes very large proportion of fragments of Charæ; but they have undergone more or less of crystalline consolidation. As examples of them, two physical analyses may be given of specimens from Binsted, which will also serve to show the character of such analyses.

1. A hard, marly-looking specimen, with numerous cavities due to the removal of the shelly matter of more or less entire Limnæans:

Empty cavities	16·3
Fragments of Limnæans	15·6
Fragments of *Chara*	11·0
Fine grains of decayed Limnæans and *Chara*	57·0
Peroxide of iron	·1
	100·0

2. A hard, even-grained specimen, with no entire or large fragments of shells visible to the naked eye:

Grains of Limnæan shell showing structure	5·7	18·0
Ditto not showing ditto . . .	12·3	
Crystallized fine granules of shell, &c. .		55·9
Quartz sand		13·5
Very fine sand and decomposed felspar .		12·1
Peroxide of iron, chiefly in the substance of shell fragments		·5
		100·0

In the above-described marls and limestones are found several curious bodies, but in no great proportion; and, on the whole, they may be said to be derived from the decay of the fresh-water shells found in them, and not from the deposition of chalky mud, which has a totally different character, though the calcareous matter in the water, from which the shells procured it, may have been derived from the contiguous chalk. It is worthy of remark, that in these marls no *Diatomaceæ* are found, though they abound in the clays associated with some of them; but the examination of tufaceous travertins has furnished the author with evidence which proves that contact for a long period with carbonate of lime decomposes and destroys their siliceous coverings, and therefore they could hardly be expected to occur in such deposits as those under consideration.

ORIGINAL COMMUNICATIONS.

Auditory Apparatus *of the* Culex Mosquito. By Christopher Johnston, M.D. Baltimore, United States.

It is more than presumable that creatures endowed with the faculty of producing and voluntarily modifying distinct *sounds*, should also possess organs for the apprehension and appreciation either of rhythmic or irregular sonorous vibrations. The insect tribes are precisely in this category; the apparatus by which is produced their song, their hum, or their chirp, is extremely varied, and the sounds which emanate from it offer a great diversity, even in the larger individuals, or, in other words, so far as our own auditory organs permit our sense to follow the rising scale. That these sounds are in some way *perceived* by insects themselves we have abundant evidence in the Cricket (*Gryllus*), the Grasshopper (*Cicada*), and especially in the Bee, which responds to another individual in a particular note.* Some insects are supposed to be silent; while the smaller varieties, from the exceeding minuteness of their parts, give rise to vibrations so rapid as to be inappreciable by our ears.

It will readily be admitted that if there be a limit for acute sounds, corresponding with the smallest number of vibrations capable of producing an auditory impression, there must also be a limit to the development of an acoustic apparatus; and "we cannot," as Dugès remarks, "conceive of a true *microscopic* ear." In the *Protozoa*, therefore, and possibly in the most diminutive insects, we may abandon the idea of a centralization of the faculty of perceiving vibrations, and feel assured that the sense of touch, generally distributed, stands in the stead of a "sensorial speciality."

From analogy, pursued downwards, we might expect to discover the localization of the "sensorial speciality," when it exists, in the *head* of insects, or else from analogy, pursued upwards, might we sometimes look for its seat elsewhere. In fact we find numerous descriptions of an auditory apparatus situated in the head of certain species, and in parts connected with the thorax of other species; but many of the observers have failed to convince others than themselves; and other writers have assigned, in some instances, a different function to the organs spoken of as being concerned in audition.

* Dugès. Physiol. Comp.

Treviranus* describes the "organ, probably of hearing" of the *Blatta orientalis*, as consisting of an oval opening, situated immediately behind the insertion of the *antennæ*, and covered with a convex white pellicle, and supposes it possible that the club-like *antenna* of the diurnal Lepidoptera contains an auditory apparatus.

Ramdohr† presumes that the vesicles placed at the root of the *maxillæ*, in bees, have a similar function.

Straus-Durckheim locates the seat of hearing in the foliated *antennæ* of the May-bug.

Carus‡ considers it possible "that the membrane, which, in the *Locusta viridissima*, unites the *antenna* with the head, and offers a tolerably extended surface, is a sort of *membrana tympani*, or membrane of a kind of *fenestra vestibularis*, which the movements of the *antennæ* may relax or render tense."

De Blainville,§ finding certain apertures like *stigmata* in the posterior part of the head of Grasshoppers, supposes that they lead into a cavity which appears to him an auditory apparatus; and Carus admits the probability of this presumption, "as deriving support from the evidence of analogous facts in the higher classes." But Dugès found the "apertures" to be simply "depressions;" and he denies positively the existence of communicating *tracheæ* and vesicles, and also of an accessory nervous expansion.

L. W. Clarke‖ describes at the base of the *antennæ* of *Carabus nemoralis*, an auditory apparatus composed of an auricle, an internal and external auditory canal, a *tympanum*, and a labyrinth.¶

Newport** believes that the *antennæ* serve as well for touch as hearing.

Siebold†† opposes the opinion of Treviranus concerning the two white convex plates existing at the base of the *antennæ* of *Blatta orientalis*, and declares them to be simply rudimentary accessory eyes. The same author gives an account of an auditory apparatus belonging to the *Acrididæ*, consisting of a *tympanum*, and a membranous labyrinth supplied with an auditory nerve proceeding from the third thoracic ganglion. The *Locustidæ* and *Achetidæ* have similar organs situated

* Cited in Traité Elem. d'Anat. comp. C. G. Carus. Paris, 1835.

† Idem. ‡ Idem., *loc. cit.*

§ Anat. comp. des Animaux artic. Paris, 1828.

‖ Magazine of Nat. Hist. 1838.

¶ But of none of which, according to Siebold, is there the least trace.—[Ed.]

** Transactions of Entom. Society, II.

†† Nouveau Manuel d'Anatomie comparée. Artic. par M. C. Th. v. Siebold. Paris, 1850.

in their anterior legs immediately below the coxo-tibial articulation. These organs are composed of a *fossa* on each side, or of two, more or less capacious, cavities (auditory capsules) with orifices opening forwards; and each having on the inner side an elongated oval *tympanum;* and the two *tympana* are in close contact with a dilatation of the large tracheal tube of the leg, whose upper extremity is in connexion with an acoustic nerve which derives its origin from the first thoracic ganglion. A neighbouring portion of the tracheal system he supposes to serve the purpose of a Eustachian tube.

And finally, J. Müller, as quoted by Carus,* regards as organs of hearing "two depressions or pits, in *Gryllus hieroglyphicus*, situated, one on each side, of the *metathorax*, on the dorsal aspect, above the attachment of the last pair of legs upon and closed by a delicate membrane, behind which there exists a vesicle, filled with liquid, which receives a nerve from the third thoracic ganglion."

While bearing in mind the difference between *feeling a noise* and *perceiving a sonorous vibration*, we may safely assume with Carus—for a very great number of insects, at least—that whenever true auditory organs are developed in them, their seat is to be found in the neighbourhood of the *antennæ*. That these parts themselves are, in some instances, concerned in collecting and transmitting sonorous vibrations, we hold as established by the observations we have made particularly upon *Culex mosquito;* while, we believe, as Newport has asserted in general terms, that they serve also as tactile organs.

The male mosquito differs considerably, as is well known, from the female; his body being smaller and of a darker colour, and his head furnished with *antennæ* and *palpi* in a state of greater development. (Plate VI., fig. 1.) Notwithstanding the fitness of his organs for predatory purposes he is timid, seldom entering dwellings or annoying man, but restricts himself to damp and foul places, especially sinks and privies. The female, on the other hand, gives greater extension to her flight, and, attacking our race, is the occasion of no inconsiderable disturbance and vexation during the summer and autumn months.

The head of the male mosquito, about 0·67 mm. wide, is provided with lunate eyes, between which in front superiorly are found two pyriform capsules nearly touching each other, and having implanted into them the very remarkable *antennæ*.

The *capsule*, measuring about 0·21 mm., is composed of a horny substance, and is attached posteriorly by its pedicle, while anteriorly it rests upon a horny *ring*, united with its

* *Loc. cit.*

fellow by a transverse fenestrated band, and to which it is joined by a thin elastic membrane. Externally it has a rounded form, but internally it resembles a certain sort of lamp shade with a constriction near its middle; and between this inner cup and outer globe there exists a space, except at the bottom or proximal end, where both are united.

The *antennæ* are of nearly equal length in the male and the female.

In the male the *antenna* is about 1·75 mm. in length, and consists of fourteen joints, twelve short and nearly equal, and two long and equal, terminal ones, the latter measuring (together) 0·70 mm. Each of the shorter joints has a fenestrated skeleton with an external investment, and terminates simply posteriorly, but is encircled anteriorly with about forty *papillæ*, upon which are implanted long and stiff hairs, the proximal sets being about 0 79 mm. and the distal ones 0·70 mm. in length; and it is beset with minute bristles in front of each whorl.

The two last joints have each a whorl of about twenty short hairs near the base.

In the female the joints are nearly equal, number but thirteen, and have each a whorl of about a dozen small hairs around the base. Here, as well as in the male, the parts of the *antennæ* enjoy a limited motion upon each other, except the basal joint, which, being fixed, moves with the capsule upon which it is implanted.

The *space* between the inner and outer walls of the capsule, which we term confidently the auditory capsule, is filled with a fluid of moderate consistency, opalescent, and containing minute spherical corpuscles, and which probably bears the same relation to the nerve as does the lymph in the *scalæ* of the *cochlea* of higher animals. The *nerve itself*, of the *antenna*, proceeds from the first or cerebral ganglion, advances towards the pedicle of the capsule in company with the large *trachea* which sends its ramifications throughout the entire apparatus, and, penetrating the pedicle, its filaments divide into two portions. The central threads continue forwards into the *antenna* and are lost there; the peripheral ones, on the contrary, radiate outwards in every direction, enter the capsular space, and are lodged for more than half their length in *sulci* wrought in the inner wall or cup of the capsule.

In the female the disposition of parts is observed to be nearly the same, excepting that the capsule is smaller, and that the last distal antennal joint is rudimental.

The *proboscis* does not differ materially in the two sexes; but the *palpi*, although consisting in both instances of the

same number of pieces, are very unlike. In the female they are extremely short, but in the male attain the length of 2·73 mm.; while the proboscis measures but 2·16 mm. They are curved upwards at the extremity.

If an organ of hearing, similar to that described by Treviranus as belonging to the *Blatta orientalis*, exist in the head of the Mosquito, the *tympanum* must be of exquisitely minute proportions, because the head, which has a diameter of only 0·67 mm., is almost entirely occupied by the corneal *plaques*, the capsules, and the attachments of the neck and of the buccal apparatus. The membrana tympani must therefore be so small as to preclude the idea of its being put in vibration by any sounds other than those infinitely more acute than are produced by the insect itself, and the use of such an organ for the purposes of inter-communication must be highly problematical. But no trace of such a disposition is to be found in the head, nor very certainly, also, in the body; and we are obliged to look for some organ which may answer the requirements of an effective auditory apparatus.

The position of the capsules strikes us as extremely favourable for the performance of the function which we assign to them; besides which there present themselves in the same light the anatomical arrangement of the capsules, the disposition and lodgment of the nerves, the fitness of the expanded whorls for receiving, and of the jointed antennæ fixed by the immovable basal joint for transmitting vibrations created by sonorous modulations. The intra-capsular fluid is impressed by the shock, the expanded nerve appreciates the effect of the sound, and the animal may judge of the *intensity*, or *distance*, of the source of sound, by the *quantity* of the impression: of the *pitch*, or *quality*, by the consonance of particular whorls of the stiff hairs, according to their lengths; and of the *direction* in which the modulations travel, by the manner in which they strike upon the *antennæ*, or may be made to meet either *antenna*, in consequence of an opposite movement of that part.

That the male should be endowed with superior acuteness of the sense of hearing appears from the fact, that he must seek the female for sexual union either in the dim twilight, or in the dark night, when nothing save her sharp humming noise can serve him as a guide. The necessity for an equal perfection of hearing does not exist in the female; and, accordingly, we find that the organs of the one attain to a development which the others never reach. In these views we believe ourselves to be borne out by direct experiment, in connexion with which we may allude to the greater difficulty of catching the male Mosquito.

In the course of our observations we have arrived at the conclusion, that the *antennæ* serve, to a considerable extent, as organs of touch in the *female;* for the palpi are extremely short, while the antennæ are very movable, and nearly equal the proboscis in length. In the *male*, however, the length and perfect development of the palpi would lead us to look for the seat of the tactile sense elsewhere; and, in fact, we find the two apical antennal joints to be long, movable, and comparatively free from hairs; and the relative motion of the remaining joints very much more limited.

On the Noctiluca Miliaris. By Woodham Webb, M.D., Lowestoft.

Mr. Huxley's interesting paper in the last number of the Journal on the structure of the *Noctiluca miliaris*, led me to review a few notes I had by me upon the subject, and to follow up certain points of inquiry which he indicated.

Unfortunately, I am not able to complete the history of this anomalous creature, though it has been under continuous examination since last July. It may, however, be worth while to record the few steps made in advance of the existing accounts, in order to save other observers some labour, and to serve as a sequel to Mr. Huxley's more elaborate communication.

The extraordinary prevalence of this creature during the present season seems to have excited general attention, and it was stated by Mr. Byerly, of Liverpool, at the last meeting of the British Association, that in consequence of their numbers the waters acquired a rose colour. This was not the case on the eastern coast, though the unusually brilliant iridescence of the water has been the subject of remark. From the month of July to the beginning of December, there has been no difficulty in obtaining an uninterrupted supply of specimens, and during that period the water has shown incessant alternations of luminosity and darkness. These conditions, therefore, depend not merely upon the presence or absence of the animal, but on some peculiar conditions of its organs, or the media acting upon them.

As a caution to those who may undertake the further examination, I may state that the buoyancy of the *Noctiluca* is such as to bring it to the surface of tranquil water without any apparent effort; and that the best way to effect its capture is, not as is most frequently done, to use the muslin net, by which means the greater number of the creatures are lost or

destroyed, but to skim the top, and especially those parts near the sides of the vessel in which the water has been standing. If removed in this way and kept by themselves in a test-tube, they may be preserved for two or three weeks without a fresh supply of water. Even at the end of that time, if they die, it does not appear to be from having reached the natural term of their existence, but as the result of some accidental cause; they will not, however, bear carriage to any great distance in closed vessels.

The following paragraphs refer to various matters, according to the order in which they occur in Mr. Huxley's paper.

The groove or depression on the body is divided into two portions by a fold of the external membrane stretching across between the protuberant and rounded masses which form its boundaries. It ends posteriorly in an acute angle, outlined by the bifurcation of a more superficial marking or channel. The stem of this forked structure is of a rigid horny nature, and is connected at the point of division with a reduplication of the internal membrane, or a prolongation of the central visceral mass. I have not been able at any time to detect an aperture at this spot, but there is some reason to believe there may be one. When the ruptured integument collapses, this straight spine may still be seen retaining its rigidity, and is the centre about which the folds arrange themselves.

The investing membrane distinctly consists of two layers. The external one is minutely reticulated, and has somewhat the appearance of pavement epithelium on a small scale. The interspaces contain granular matter. With this exception it is perfectly smooth, and I can find no trace of cilia. Illuminated by a parabolic condenser, the whole surface is seen studded with brilliant glittering points, apparently at the junction of the reticulations of the internal fibres with the integument. I have never been able to develope luminosity under the microscope.

The internal layer is at all points in union with the whole system of reticulations spreading from the central organs. This was made manifest by the action of indigo. None of the colouring matter entered the body, but death ensued in about an hour's time. Irregular jerking movements took place, the oral aperture and parts about it became distorted, though the motions of the *cilium* and tentacle still continued. The internal fibrous reticulations gradually contracted, drawing the "vacuoles" together, and with them the inner membrane. This was detached without rupture, but after a time fell into folds, which so included the other structures as to have the look of a wrinkled tube with a series of pouches ending in a

arger membranous sac. The external layer distended by degrees till it suddenly burst. I should mention that a new supply of water had been given before most of these changes happened. I have also been successful in separating the two layers mechanically, by means of pressure slowly and steadily applied to the animal under the screw compressor. The whole internal network of fibrous tissue, with the manner in which it invests the so-called " vacuoles," is most beautifully demonstrated by the effect of iodine. The creature dies suddenly without collapsing. The progress of the fluid can be traced along the fibres into the minutest meshes ; and there remains for a long time a transparent ball, traversed in every direction by the brown fibres, beaded with the vacuoles and granules, and having every reticulation on the surface sharply defined.

I am inclined to regard the tentacle as tubular, with an orifice on the inner side at its base. At any rate, I have seen the colour, when iodine has been used, proceed slowly towards the distal extremity ; and under the influence of indigo poisoning, the granular matter of which the striation consists, has been disarranged, scattered up and down the interior of the organ, and in the end has aggregated together in small globules without much impairing the power of motion. I recognize no trace of striation in the external membrane ; and when seen in the normal condition by transmitted light, there is always a clear substance surrounding the dark centre. This gives the impression of being made up of a series of discs or rings. The tentacle is extremely brittle, and breaks with a short fracture. I have never perceived any tendency to restoration of the lost part, nor any independent movement in the detached fragment. The stump continues active, and readily comes off at the base. The point is a little flattened. When the animal is killed in such a manner that this organ has free play, it always shows a disposition to coil up spirally. The cilium may be found in every instance in which it is looked for with a quarter-inch glass,* or even with the half-inch, provided the creature is left at perfect liberty, and is made to move, if not in the right position. It often remains at rest for some time, and then from above looks like a small bright spot at the base of the " tooth ;" or it may occasionally be seen extended over the S-shaped ridge, or even the base of the tentacle. I have many times detected it in motion from behind through the intervening substance of the body ; and have noticed it vibrating vigorously long after rupture of the integument and partial discharge of the contents. A Chara

* I use a quarter-inch glass of Pillischer's, or a 1-5th of Smith and Beck's make.

trough or shallow concave cell is most convenient for observations on this part, as the animal swims close to the under surface of the thin glass, and may be made to turn in any direction.

The ridge and tooth can scarcely be overlooked. This ridge is of fibrous structure, and may sometimes be observed in regular contractile action. Corresponding with these contractions, I have witnessed a to-and-fro motion of the tooth, as though working on an axis, in a direction towards the base of the tentacle. A good illustration of this performance is given by bending the fore and middle fingers and flexing them on the palm of the hand. The tooth when seen in profile has the appearance of a conical papilla (Plate VI., fig. 6), or with a slight change in the point of view, of a hooked process terminating in a sharp nib (figs. 8, 9). It readily yields to pressure, and I have seen it become shrivelled up from the use of astringents, before motion ceased in the cilium and tentacle.

The "vacuoles" are alimentary sacs. When empty, they are usually contracted and grouped near the membranous tube which leads from the oral aperture, a few only being scattered among the internal reticulations. Their situation is constantly changing, sometimes with a steady advance, at others by jerks; while the fibrous meshes with which they are connected undergo a relative alteration in shape. Gentle pressure will occasionally expel them through the oral or anal aperture; but I have seen them spontaneously ejected without rupture, and float away from the body. In one instance where this occurred, and where the contents consisted of granular matter, fragments of Diatomaceæ, and particles of sand, the sac remained entire for some time. When it burst, the membrane doubled up, the contents escaped, and the bits of silica were characteristically shown with the polariscope. I have never known these gastric pouches, or alimentary substances to be voided by any other outlet than those connected with the central depression.

The position of the second aperture, or *anus*, communicating with the gastric pouch, appears to me to be at the posterior end of this depression, on the side opposite to the tooth, and somewhat further back (fig. 7).

The mode of reproduction is at present far from being satisfactorily made out. I have never met with a double individual, but on one occasion witnessed the process of division, without, however, noting any proof of its connection with that of fissiparous multiplication. Contractions of the integument took place in such a way as to cut off a globular

mass from the body, about one-fourth of the whole. The two portions afterwards retained their form with a puckered mark at the point of separation. The *nucleus* was not involved in this operation, which occupied about two hours.

It is also a matter of every-day observation, that when the body has been torn and nearly all the contents have been lost, the animal continues to live in a deformed state, if the *nucleus* and central parts are left together. They acquire a new investment, or a portion of the original integument gathers up round them, while the ragged shreds are cast off.

When several of these creatures have been kept for some time in still water, it is not unusual to find two of them in apposition; but I have never discovered any indications of conjunction, and look upon the condition as one of mere adhesion. It may, however, have given rise to the mention of double individuals, as the adhesion is tolerably firm. It may easily be broken up without injury to either animal.

The nucleus may be demonstrated as a nucleated vesicle, sometimes solitary, more frequently with several similar, but smaller nucleated vesicles grouped around it. By careful manipulation it may be removed from the other structures. As it floats about, the true form is displayed. Seen in one position, you have a view of a round vesicle with a smaller vesicle attached to it by a sort of hour-glass contraction; in another, of a round vesicle with a central spot, a nucleated cell.

I have found the nucleus enclosed in a second membranous envelope, with a granular yelk-like fluid, which could be seen pouring out when the membrane gave way (fig. 10).

Beyond this point I have not been able to trace the nucleus.

On the Nature *of the* Torbanehill *and other* Varieties *of* Coal. By Peter Redfern, M.D., Lond., Lecturer on Anatomy and Physiology, and on Histology, in the University of Aberdeen.

(Read at the Meeting of the British Association for the Advancement of Science at Liverpool, 1854.)

The substances to which I intend to allude in the following paper, under the name of coal, are such as, *known commonly as coal, consist of compressed and chemically altered vegetable matter, associated with more or less of earthy substances, and capable of being used as fuel.*

Though I shall confine myself chiefly to the structural characters which coals present, I shall refer briefly to their chief

geological and chemical relations; for it is my firm conviction, that if the geological, chemical, and microscopical characters of such substances do not mutually illustrate and confirm each other, the truth has not been arrived at.

It is my chief object to bring forward a number of facts, which I have arrived at after a prolonged investigation, and to detail the method which I have followed in such a way as to enable every reader to repeat my observations, and either to confirm or disprove them.

I have taken the greatest care to obtain authentic specimens, if possible, from different sources, and I have examined none of the perfect authenticity of which I had not the most certain evidence. I have carefully examined *complete sections* of the beds of coal of most importance in the inquiry. I have broken up these masses, and examined the beds with the naked eye from top to bottom. In the case of the Torbanehill coal I have made thin sections horizontally, and in two directions vertically, at distances of a few inches through the thickness of the bed, to determine the structure of the whole; and I have likewise examined the coals when reduced to powder and coke. I have examined upwards of 200 sections, and other microscopical preparations of different coals, of which 180 were prepared by my own hand from specimens, the perfect authenticity of which I can easily prove. In the whole examination I have endeavoured to make out every fact as it presented itself, and to adopt no explanation not consistent with the whole, and with the evidence derived from every means of observation. Yet I have no wish that anything which I may advance should be taken for granted. I am prepared to prove every statement of facts by the preparations on which my observations were made.

The Torbanehill coal, which has recently excited so much attention, owing to the well-known jury trial, Gillespie *v.* Russel, is found in the coal-measures of the lands of Torbanehill, in the parish of Bathgate, county Linlithgow. It forms a bed, varying in thickness from 1 foot 4 inches to 1 foot 11 inches, becoming darker in colour, coarser in texture, and less valuable as a gas coal, at Bathvale, on the west of the lands of Boghead; and very much coarser, and less valuable still, at Barbachlaw, about half a mile to the north-west of Boghead, where the seam is worked by the Monkland's Iron Company.

The position of the bed does not differ from that of a bed of coal. It has a thin layer of cement-stone immediately above it, varying in thickness from half an inch to two inches.

Above that is a bed of shale, varying in thickness up to four feet. Immediately below the bed is a stratum of fire-clay, with occasional ironstone-balls, about two inches thick, and very full of the impressions of plants. Under that is a layer of good bright-looking coal of six inches in thickness. Occasionally a thin layer of common coal runs through the cannel, and is variable in thickness. It appears, therefore, that the bed is in a similar geological position to that of other cannel coals.

In working the coal, it is got in rhomboidal blocks, extending through the whole thickness of the seam, and measuring from six to sixteen inches in breadth, and from five to fifteen in depth (back). The fracture perpendicular to the plane of stratification is conchoidal, that parallel to the same plane is slaty. The colour is of a light brown, and the streak yellow and dull in the upper part of the seam; in the lower part the colour is, in many specimens, as dark and lustrous as that of many other cannels, and the streak varies in a like proportion.

When viewed chemically (I now quote from the evidence of Dr. George Wilson, one of the pursuer's witnesses at the late jury trial), "There is no ingredient in common coal that is not at all present in the Torbane mineral. There is no ingredient in Torbane mineral that is entirely absent from all known coals."

But there are some chemical peculiarities. The quantity of earthy matter is large, 18 per cent.; but many well-known coals contain a still larger quantity. The fixed carbon is small in quantity, but analyses of other coals have shown less; and the total carbon is quite equal to that in other cannel coals—$65\frac{1}{2}$ per cent. (Hoffman and Stenhouse). The hydrogen is in very large quantity ($7\frac{1}{2}$ to 9 per cent.), but even in this particular the Methill coal approaches very closely; for Professor Anderson found 7·54 per cent. in it.

The following tables, copied from a paper by my esteemed friend Dr. Fyfe, published by the Royal Scottish Society of Arts, will be found of great value in comparing the Torbanehill with other coals. To the whole of that paper I may refer as a statement of a mass of facts, unquestionably proving that the Torbanehill mineral is similar in every chemical relation to other coals.

On this table Dr. Fyfe remarks: "That the proportion of volatile matter of the coals varies from about 37 to nearly 67 per cent.; of course the coke varies from about 33 to 63. The proportion of fixed carbon and of ash in the coke also varies;

the former being from about 18 to 52, the ash from 3·6 to 28·5."

TABLE of the Proportions of Volatile Matter, of Coke, of Fixed Carbon, and of Ash, in 100 parts of different Coals, and in the Torbane Mineral.

COALS. c. cannel. h. household.		Specific Gravity.	In 100 parts of Coal.		Coke.		In 100 parts of Coke.	
			Volatile Matter.	Coke.	Carbon.	Ash.	Carbon.	Ash.
Wigan, Ince Hall .	c.	1255	37·6	62·4	56·0	6·4	89·7	10·3
,, ,,	c.	..	37·7	62·3	50·5	11·8	81·0	19·0
Torbane household	.	..	38·3	61·7	52·5	9·2	85·0	15·0
Kinneil. . . .	c.	..	44·4	55·6	44·4	11·2	80·0	20·0
Donibristle . .	c.	1237	46·5	53·5	49·2	4·3	92·0	8·0
Capledrae (2nd) .	c.	1310	47·2	52·8	24·3	28·5	46·0	54·0
Knightswood . .	c.	..	47·5	52·5	48·5	4·0	92·4	7·6
Balbardie . . .	h.	..	43·6	56·4	29·8	26·6	52·8	47·2
Lochgellie . . .	c.	..	50·4	49·6	36·2	13·4	73·0	27·0
Disco Island . .	h.	1384	50·6	49·4	39·6	9·8	80·0	20·0
Monkland . . .	c.	..	54·2	45·8	39·5	6·3	86·2	13·8
Lesmahago . .	c.	..	57·4	42·6	39·0	3·6	91·5	8 5
,, . .	c.	..	58·3	41 7	35·3	6·4	84·6	15·4
Methill	c.	..	59 0	41·0	18·5	22·5	45·0	55·0
Capledrae (1st) .	c.	1238	59·1	40·9	33·2	7·7	18·8	81·2
Wemyss . . .	c.	..	66·6	33·4	21·9	11·5	65·5	34·5
Torbane . . .	c.	..	66·9	33·1	15·6	17·5	47·1	52·9
,, . . .	c.	..	68·1	31·9	14·5	17·4	45·4	54·6
,, . . .	c.	..	68·4	31·6	8·6	23·0	27·2	72·8
,, . . .	c.	..	69·0	31·0	9·3	21·7	30·0	70·0
,, . . .	c.	..	69·8	30·2	13·1	17·1	43·3	56·7
,, . . .	c.	..	69·8	30·2	6·6	23·2	29·8	70·2
,, . . .	c.	..	70·1	29·1	16·3	12·8	56·0	44·0
,, average .	.	1199	68·8	31·2	11·9	18·3	38·4	61·6
Tree in Torbane .	.	..	68·8	31·2	10·8	26·4	34·6	65·4

"The average per-centage of these ingredients in Torbane mineral is 69 of volatile matter, 31 of coke, 12 of fixed carbon, and 18 of ash. It does not, therefore, differ from coals excepting in two particulars: viz., that it yields more gaseous products and less fixed carbon. But even in these the difference is very trifling; being only about 2·4 per cent. more than that of the former from Wemyss' coal, and 8·5 less of the latter than from Methill coal: indeed, some of the samples of Torbane contain only 2 per cent. less. The per-centage of ash in some of the samples is less than in several of the coals; and the average quantity is not so great as that of Methill and Capledrae."

TABLE showing the average proportion of the different (ultimate) ingredients of Coal and of Torbane Mineral.

COALS.	Carbon.	Hydrogen.	Oxygen.	Nitrogen.	Sulphur.	Ash.
Scotch	80·72	6·1	8·45	1·32	1·25	2·16
Welsh	81·44	5·01	7·36	0·83	1·66	3·8
Newcastle . . .	84·3	5·86	6·37	1·28	0·68	1·51
Derbyshire . .	79·65	4·96	10·17	1·48	1·07	2·69
Lancashire . .	76·53	4·95	11·52	1·22	1·21	4·51
Foreign . . .	65·82	3·56	7·17	1·3	1·05	21·1
Capledrae . . .	56·77	6·79	8·79	1·9	0·35	25·4
Torbane . . .	60·25	8·86	3·62	1·53	0·13	25·6

Dr. Fyfe says, "The Torbane mineral, in a chemical point of view, resembles coal. It has in it all the component parts of coal, and in nearly the same proportions as in some of them. It does not contain anything that is not found in coals. It yields the same products by distillation, at different temperatures; such as gas for illumination, tar, and ammoniacal liquor, benzole, naphtha, naphthaline, pitch oil, paraffine oil, and paraffine. I have shown also that it differs materially from asphalt, and from shales, and bituminous shales, in containing almost no bitumen."

So chemistry points out that the Torbanehill coal is made up of the same substances as compose other coals, and that such proportions of these individual substances as exist in it are also found in other coals. Further, its chemical composition points clearly to its formation from the organic kingdom of nature.

When a thin piece of this coal is lighted at a flame it burns like a candle, hence such coals have been called candle or cannel coals; when a piece is thrown on the fire it crackles in splitting to pieces, and for that reason it and such like coals are called parrot coals.

Structure of the blocks in which the coal is found naturally and solid. They are very tough, elastic, and difficult to break, unless they are struck on their sides with a sharp-edged hammer, or with a knife and hammer; the blocks then split into thin layers with great ease. I have split 16-inch blocks in this way into 16 layers of one inch in thickness, without breaking more than one of them. Yet not one entire piece can be split off in the vertical direction by any means whatever. If the hammer be applied perpendicularly to the surface of the bed, the fracture produced is conchoidal.

One great fact has thus been arrived at: the whole bed of Torbanehill coal is laminated. I think the importance of this fact has not yet been thoroughly understood.

In every part of the coal very evident fossil plants are found. Some are in the shape of large trunks of trees, fluted vertically on the surface, and one to two feet in diameter. The most numerous are Stigmariæ, of various sizes, flattened, and sending off abundant rootlets into the mass. I do not believe that a single fractured surface can be shown which does not present portions of fossil plants, and these are in every respect similar to those found in other coals, but far more numerous than they.

Every fractured surface likewise shows a number of angular, flattened facets, on different planes from that of the general surface of the fracture. These occur everywhere in the bed. Not a cubic inch of the coal can be got without them ; they, too, are impressions or portions of fossil plants. When examined with a pocket-lens, or a low power of the microscope, these surfaces, and the larger surfaces of the more obvious fossils, present similar appearances, and show, over spaces not unfrequently of many inches in extent, the scalariform tissue so abundant in ferns, or some closely allied vegetable tissue. The vessels of this tissue present themselves on their sides, and in various oblique and transverse sections in the different parts.

If it be borne in mind that a very large portion of the whole bed of coal is made up of such easily recognisable vegetable structures, and that $65\frac{1}{2}$ per cent. of the mass is carbon, I think but little difficulty will be experienced in arriving at the conclusion that it owes its origin almost entirely to the vegetable kingdom.

Before leaving these fossils, it is to be carefully noticed that it is only when the fracture has exposed them in a particular way that they are thus distinguished from the mass in which they are imbedded. For the most part, the appearances they present on any but their natural surfaces are exactly those presented by the mass. When a fossil stem is carefully separated from the coal, and its surfaces are recognised as natural faces presented by the plant, one is surprised to find that the structure of thin sections made through it does not differ from that of thin sections of the whole bed, except where scalariform vessels appear. Now, there is no ground for the belief that there ever was a plant containing scalariform vessels, of which the greater part was not composed of a softer and cellular mass ; and there is just as little reason for supposing that, where the shape of a plant and its scalariform vessels have been so perfectly preserved, there would be no trace of its other structures. So, when it is shown that there is a very remarkable arrangement of the parts of these

fossils, and that the same arrangement, in all its essential features, exists in all of them and in the substance in which they are imbedded, I think that good, if not altogether conclusive, evidence is offered, that the bed of coal which contains fossil vegetables, and has everywhere the same essential characters of structure and chemical composition as those fossils, is itself a bed of vegetable matter.

Let us now pass from these general observations to more special ones, less easily made and understood. Cut a small block of coal from the Torbanehill bed, say of one inch long, two-thirds of an inch wide, and half an inch thick, so that its upper and lower surfaces shall be exactly parallel to the surfaces of the whole seam ; polish its faces, and having coated them with varnish, or covered them in turn with a drop of oil, examine them with magnifying powers from 5 to 100 diameters as opaque objects. The upper and lower surfaces of such a block are alike, and the sides and ends are alike, but widely different in appearance from the upper and lower surfaces.

The top and bottom of the block are studded with more or less rounded yellow spots, closely set in a darker mass ; the sides and ends present a number of elongated yellow spots in a darker mass. Such appearances are presented by the surfaces of all such blocks, from whatever parts of the bed of coal they may have been taken ; but they are least obvious in the upper part of the seam, and are more easily recognised the lower the part examined. These appearances I believe to be produced by rounded yellow masses, flattened above and below.

There are also to be seen on all such blocks irregularly elongated and angular black patches, and branching black lines, which run in various directions on the upper and lower surfaces, but for the most part in the direction iu which the coal splits on the sides and ends. Near the top of the seam, crystals are seen scattered on all the surfaces of the blocks.

The appearances presented by the surfaces of small blocks, I think, have been mistaken in the case of other coals for evidence of their consisting of woody tissue, whereas they are merely the result of the laminar aggregation of the structures of which beds of coal are formed.

Let us for a moment examine the differences presented by a block of wood and one of coal. If we take such a block as that of which I have spoken from the trunk of a tree, so that its upper surface would look towards the branches, and the lower towards the root, these surfaces will present us with a number of rounded openings and rings, which are the cut extremities of the vertical fibres and vessels of which the wood

is made up; whilst the sides and ends of the block will be striated *vertically*, because they show the sides of the fibres and vessels, which have been separated from each other in their course.

The block of coal presents rounded yellow spots above and below, and *horizontally* striated sides and ends. Now, there is this wide difference between the wood and coal—that wood is composed of a multitude of fibres and vessels, arranged vertically in a tree, and therefore cut across by a horizontal section, and separated from each other so as to produce a vertical striation on every vertical section, make it where you may. Coal, on the other hand, consists of a multitude of thin laminæ, applied upon each other like the leaves of a book. These laminæ are made up of rounded yellow bodies, flattened above and below, imbedded in a darker mass, and so on every horizontal section these bodies are separated as one would lift off the coins of a pile from each other; whilst a vertical section passes through them as such a section would through the pile of coin.

There is, therefore, as much resemblance between a block of coal and one of wood as there is between a substance composed of a series of laminæ, and another made up of a number of fibres closely packed together.

We now turn to the appearances of *thin sections of the Torbanehill coal*, when examined by high powers of the microscope.

I think it will be obvious, from what has been said, that the nature of any substance which can be examined by sections may be made out if such sections are made horizontally at different depths, and vertically in several directions, so that the planes of these vertical sections are at various angles to each other. Or, if we cut sections from the top or bottom, and from the side and end of such small blocks as those before named, these will enable us to judge of the nature of the structures of which the mass is composed.

Pieces of coal may be split horizontally from a block with a knife and hammer with great ease for making thin horizontal sections; but, for vertical sections, a saw or the diamond-wheel of the lapidary must be made use of. All sections of the Torbanehill cannel may be ground sufficiently thin by the hand without being cemented to a slip of glass in the ordinary way. This plan is far more satisfactory in its results than any other I have tried, and is much less likely to lead to error, from destruction of tissue or obliteration of it by the materials used in making the sections. I have 26 sections, horizontal and vertical, which I prepared in this way from the same

block of coal. To ensure accuracy, I made sections in three places, at different depths, in half an inch of cement-stone at the top; and others in the coal, at distances of 2, 4, 6, 10, and 16 inches from the top of the seam. The results were precisely similar to those which I obtained from sections prepared from numerous other blocks of the coal obtained from a great variety of sources. At each part of a bed of coal examined I have made at least three thin sections, and distinguished these from each other by the letters H. S., for horizontal sections; V. S. a., for vertical sections taken from the side of a small block; and V. S. b., for vertical sections cut from the ends of such blocks. Having bestowed the greatest care in the investigation, from beginning to end, I feel assured that other observers will corroborate my facts and the correctness of my drawings, from which the accompanying plates have been executed, however different their conclusions may be from my own.

Horizontal sections taken from all parts of the Torbanehill coal, except about the upper two inches, show:—

1st. A number of irregularly rounded spots of a lemon-yellow colour, varying in diameter from about 1-250th to 1-800th of an inch, and bounded by dark-brown matter, which separates them from each other (Plate VII., fig. 3), or from, 2nd, smaller yellow patches, of a distinctly angular and polygonal shape, having a very uniform diameter of 1-1500th of an inch, and a dark-brown outline, which in many places is distinctly double.

Vertical sections show these yellow spots elongated, measuring about 1-300th to 1-1200th of an inch horizontally, or in the direction of the laminæ of bedding, and from 1-500th to 1-1900th of an inch perpendicularly to these laminæ and the whole bed (Plate VII., fig. 4). In whatever direction a vertical section is made, the appearances which it presents are the same. In every one there is a general horizontal striation; *i. e.*, having its striæ parallel to the laminæ of bedding. In horizontal sections there is no striation whatever.

Here are two points of such primary importance in the inquiry into the real nature of the Torbanehill and other coals, that I cannot do them sufficient justice without a slight digression from the preceding account of the appearances of sections.

I have before stated that a small block of coal with six surfaces presents two appearances when examined as an opaque object: one on its upper and lower surfaces, and the other on its sides and ends. One appearance is that of a number of rounded yellow spots in a black mass; the other,

that of a number of elongated yellow spots, so close together in the same mass that the black matter between them forms black striæ parallel to the laminæ of bedding. I have now shown that thin horizontal and vertical sections of the coal differ in the same manner and degree: horizontal sections showing rounded yellow spots with dark-brown boundaries; and vertical sections, elongated yellow spots with dark-brown boundaries, like dark striæ running in the direction of the laminæ of bedding of the coal.

I stated at the outset that the coal will split with great ease horizontally, but in no other direction. I would now point to such vertical sections of coals as have been prepared without having been cemented to the glass slide, for the most positive proof that all such sections break up with great ease in the direction of the striæ parallel to the laminæ of bedding, whilst such a tendency to split is never observed in horizontal sections.

I explain the tendency to split, which exists in all vertical sections but never in horizontal ones, by the wide differences in the microscopical characters of such sections; and I think it need scarcely be observed, that the characters presented by the whole bed of coal, by small blocks when examined by low powers of the microscope as opaque objects, and by thin sections examined by high powers, mutually illustrate and explain each other.

The only professedly complete account of the structure of the Torbanehill as compared with other coals was given about nine or ten months ago, in a paper read before the Microscopical Society of London, and published in the last volume of its Transactions. This paper, it is stated, was founded on an examination of sections of most of the well-known varieties of British coal, and supported by drawings and an extensive series of preparations. Its conclusions, moreover, appear to have received the assent of the Society; for the President stated in his published address that "the paper clearly demonstrates the presence, not merely of the remains of plants, but of a peculiar woody structure in every description of coal, and the absence of this peculiar structure in the mineral in question."

There appear to be two very important statements in that paper, on which its conclusions are founded:—1st. That in the Torbanehill coal there is "no difference in structure whichever way the section is made;" and, 2nd, that a cubical fragment of coal "on four of its six sides, in certain lights, will exhibit a fibrous appearance, like a longitudinal section of wood;" again, that "transverse and longitudinal sections"

of coal "are totally different, but both agreeing with corresponding sections of wood."

First, the Torbanehill coal shows "no difference in structure whichever way the section is made." My conclusion is exactly the reverse:—That there is always a remarkable difference in horizontal and vertical sections of Torbanehill coal; and to this I add, that that difference is of the same kind as the difference which exists between horizontal and vertical sections of other coals.

In evidence of the correctness of my observation I refer, 1st, to the illustrations accompanying this paper; 2nd, to confirmatory photographic representations of different sections which I exhibited at the last meeting of the British Association; 3rd, to all horizontal and vertical sections prepared in the way I have directed, as they all show a very marked difference even to the naked eye; and, 4thly, to the fact that the Torbanehill coal will only split in one direction; in itself furnishing undeniable evidence of there being some difference in the arrangement of the structure in different directions.

Second, a cubical fragment of coal "on four of its six sides, in certain lights, will exhibit a fibrous appearance, like a longitudinal section of wood;" and "transverse and longitudinal sections" of coal "are totally different, but both agreeing with corresponding sections of wood." My conclusion is, that a cubical fragment of coal on four of its six sides exhibits a striated appearance altogether unlike that presented by a cubical fragment of wood, and produced by the laminar aggregation of the structures of the coal. To support my conclusion, I simply draw attention to the fact, that if I cut a piece of wood across the direction of the striæ on one of its surfaces I see a number of rings, which are the cut ends of the woody fibres and vessels; but if I cut a piece of coal in the same way, I only find other striæ produced by its laminæ, as if I were to cut in various directions across the leaves of a book. Again, it is stated "that transverse and longitudinal sections" of coal "are totally different, but both agreeing with corresponding sections of wood." I conclude that, though horizontal and vertical sections of coal differ, both are also entirely and essentially different from corresponding sections of wood; for, whilst all vertical sections of coal present the same horizontally-striated appearance, corresponding sections of wood present striæ arranged vertically. If we cut across the striæ of wood we see the ends of its fibres and vessels; but when sections are made across the direction of the striæ of coal, other striæ appear; for the simple reason

that the striæ of wood are produced by fibres and vessels, but the striæ of coal are due to its formation of laminæ.

We now return to our examination of the appearances of thin sections of Torbanehill coal:—

Many of the larger yellow spots of horizontal sections (Plate VII., fig. 1) are lobed, as if compounded of three or more smaller spots joined together. In the greater number of these, more or less distinct double lines, which radiate from the centre of the spots, divide them into a number of polygonal spaces, more highly coloured than the spaces between the double lines, and often presenting at some part a still darker spot in each. This delicate division of the yellow matter into polygonal masses is most obvious when preparations are preserved in Canada balsam, and almost entirely disappears when sections are preserved and examined in fluid. A similar radiate striation exists in the corresponding reddish-yellow bodies of the Wemyss coal (Plate VII., figs. 5 and 6). But it happens very commonly that the dark-brown matter of the boundary of these spaces stretches into them for some distance in lines at times reaching to their centres, where there are other dark-brown lines arranged in a radiate (often a tri-radiate) manner. These lines are quite permanent in whatever medium the sections may be examined.

The action of heat offers great assistance in the determination of the nature of the yellow spots. It dissipates the whole of the yellow colour, and leaves angular and polygonal openings in the thin section, bounded by the dark-brown matter, which it has slightly blackened (Plate IX., fig. 2). It can now be determined, even upon a single section, that the boundaries of the yellow matter form definite walls for all the smaller spaces, for where the section has passed directly through the wall, this is shown by a broad, sharp, black line; but where it has cut the yellow mass near its upper or lower wall, there is a shading from the edge of the spot towards its centre, as would be the case if the boundary were formed of vegetable membrane. But further, in such yellow spots as present no very clear indication of the existence of membranous septa in their interior, heat often renders the existence of such septa as obvious as in other parts. A yellow spot is shown in fig. 2, from half of which the yellow matter has been entirely driven off, whilst it remains in the other half. In the half least acted on by the heat, this agent has blackened septa which before were scarcely visible; and, in the other half, such septa are seen to form the boundaries of spaces of a regularly angular and polygonal shape, and of the same size as those which constitute the smaller yellow patches of fig. 3, Plate VII.,

The appearance of the sections to which heat has been applied is quite sufficient to determine the fact that the gas-giving power of this coal depends upon the yellow matter, the amount of which is indicated generally by the light colour of the coal. No coal is so yellow as this in thin sections, and there is none which approaches it in gas-giving power. Torbanehill coal produces 15,000 cubic feet of gas per ton, and the best of the other known coals will not yield more than 12,000 cubic feet per ton. It may be suggested, that the dark boundaries of the spaces from which the yellow matter has been driven off by heat consist of earthy matter; but I think no one would arrive at that conclusion who had tested their strength by pressure and friction between two glasses when the preparation was immersed in viscid balsam. I do not doubt that the earthy matter has been left by the heat with the free carbon of the texture, and I think the absence of all crystalline or other obvious earthy particles in the middle and lower portions of the seam sufficient proof that the 18 per cent. of earthy matter which chemistry proves to be present in the coal has got there in a state of solution, or of fine molecular subdivision.

Now, what conclusions can be drawn from these facts as to the nature of the yellow spots? They are more or less circular, flattened, solid bodies, containing a large portion of the gas-giving substance of the coal, and bounded by vegetable fibres and membranes often in a fragmentary state. Heat drives off their yellow matter in the shape of gas, and shows in their very substance polygonal cavities with definite walls, where, without heat, such cavities and septa could not have been supposed to exist. I cannot explain the nature of these bodies otherwise than by supposing them to have had their origin in a mass of vegetable cells and tissues which have been disintegrated and otherwise changed by maceration, pressure, and chemical action, and subsequently solidified. Moreover, exactly similar bodies make up a large portion of cannel coals generally. I would especially refer to the Wemyss, Methill, Capledrae, and Rochsoles coals. Of these the Wemyss coal is especially remarkable in showing the radiate striation of the yellow masses of the Torbanehill coal; and, if I am not greatly mistaken, it demonstrates a clear relation between the yellow bodies just named, and the dark rings of horizontal sections of Lesmahago, Kinneil, Lochgelly, Wigan, and other cannels, which have been described as transverse sections of vessels or fibres.

But there are smaller and more regular yellow spaces, having far more definite walls, sometimes double (Plate VII,

fig. 3). These are found in every part of the coal, in greater or less number, and they occur also in patches in the cement-stone covering it. They are almost exactly of the same size as the polygonal spaces shown in Plate IX., fig. 2, to illustrate the action of heat. I can conceive no other interpretation of these spaces than that they are actual vegetable cells, much less changed than those before named.

3rd. The dark-brown material between the yellow masses is very scanty and granular where these masses almost merge into each other; elsewhere it is in considerable quantity, and is studded at slight intervals with patches of a yellow, red, brown, or almost black colour, in shape elongated, angular, rounded, bifurcate, and bent or even coiled. These make up a large portion of the whole substance between the yellow masses.

In vertical sections, this dark-brown matter forms lines which traverse the section in the direction of the laminæ of bedding, and are obviously the same lines as give the striated appearance to the surfaces of small blocks examined as opaque objects. The edges of vertical sections (Plate VII., fig. 4), are very instructive, for on them the vegetable fibres and shreds of membrane which are seen indistinctly in the substance of the sections project boldly, so as, I think, to compel the observer to one conclusion, that they are vegetable tissues. The dark-brown matter separating the yellow or reddish-yellow masses of other cannels is of a similar kind to that in the Torbanehill.

The general structure of the Torbanehill coal is further illustrated by occasional opportunities of examining the relation which exists between it, as shown in Plate IX., figs. 3 and 4, and portions of easily recognisable vegetable structure. In fig. 3, an irregularly elongated, brownish-red mass, without obvious structure, lies in coal having the same appearances as that found in the lower part of the seam, and shown in Plate IX., fig. 4; and it will be observed, that from this mass the septa between the yellow bodies of the coal appear to radiate. In other parts similar masses are seen in a structure more like that observed in the upper parts of the seam. In these, too, the brownish-red matter stretches into the yellow, and marks it out into a number of spaces. Again, in Plate IX., fig. 4, a band of reddish and apparently fibrous matter spreads out over a considerable quadrangular space, dividing it into polygonal yellow spots; and, on leaving it at the opposite angle, what appear to be fibres are again collected into a narrow band.

From the general description of the structure of this coal,

I excepted about the upper two inches of the bed, because the yellow spaces there are much less visible, and there is more uniformity in the appearances of various parts of sections. Yet though the yellow matter of the upper part is not so obviously marked out into spaces by the dark-brown substance, that part being, I presume, less carbonised than those lower in the seam, the mass consists of alternate patches of yellow and reddish-brown matter, and presents a very marked difference on horizontal and vertical sections. The vertical sections of this part always show reddish-brown bands or patches, sometimes branching, and always extending in the direction of the laminæ of bedding, like the dark-brown bands of vertical sections in the lower part of the seam (Plate VII., fig. 2). A very gradual change of appearance is noticed on passing from the upper to the lower parts of the seam, and in each of these parts there are occasional patches which present the ordinary appearances of the other, so I have no doubt that originally both were formed nearly in the same way.

Crystals which polarise light very highly exist in all the higher parts of the bed, but they are not found in the lower. One is shown in Plate VII., fig. 2.

4th. Every horizontal section presents a number of more or less rounded or angular bodies, in colour yellow, red, or brown, and in size measuring from 1-500th to 1-2000th of an inch (Plate VIII., fig. 5). Most of them occur singly, but occasionally two, three, or more lie close together; and I have a preparation in which is a group of fifty or sixty of the smallest of these bodies. When they occur singly, I think four or five may generally be seen in a field of the microscope of about 1-60th of an inch in diameter. Sections taken from the upper part of the bed are most favourable for their examination, because such sections are of a lighter colour than others, and can be made much thinner than they without breaking.

In vertical sections, such bodies are always found elongated (Plate VIII., fig. 6), their length being equal to the diameter of the spots shown on horizontal sections, and their breadth varying from 1-4000th to 1-1300th of an inch. Some of them present the appearances of coiled fibres, and I believe that such are either fragments of scalariform vessels, or portions of fibre, probably from spiral vessels or cells. Others are circular, both on horizontal and vertical sections, and are undoubtedly spherical cells. Many which are somewhat angular have an obviously double outline, like cells with thick walls, and they have small conical or blunt projections studding them externally. Some have lost their definite outline at particular spots, as if they had suffered from pressure or

chemical changes. I know of no interpretation of these appearances, except that they are produced by free vegetable cells, such as spores or pollen grains; but yet I cannot confidently affirm that they are such. Whatever they are, they are always to be found in other cannel coals.

5th. Scalariform tissue. Wherever a stigmaria is large enough to admit of removal from the coal, scalariform tissue may be found in it by thin sections, or the places where the tissue exists may be selected by a common pocket lens from any piece of coal containing fossils, as before pointed out. In some places, the side view of these vessels shows their ladder-like character nearly as well as a section of a fresh fern, as in the section from which Plate IX., fig. 1, was taken; but generally only very small portions of the vessels are found in a tolerably entire state, the rest being bent or broken into fragments of such small size, that of themselves they could not be recognised as belonging to such tissue at all. Such are some of the fragments found in the dark matter bounding the yellow bodies of the coal. The influence of the agent which has broken up this tissue may be distinctly traced in my preparations from parts which show distinct scalariform tissue, to others which present a uniform brownish-red mass devoid of all appearance of structure. The absence of scalariform tissue in a large number of sections by no means proves that its occurrence in the coal is merely accidental, for I have already pointed out that on all pieces of the coal containing stigmariæ, scalariform tissue can be seen in great quantity by a common pocket lens. Why it does not appear more commonly on sections, made promiscuously in the coal, will easily be understood by all who have experienced the difficulty of obtaining thin sections of pieces of coal containing a structure so different in density from its other parts as scalariform tissue. This tissue exists plentifully in other cannel coals. I have a piece of Capledrae coal, which has a surface of three or four square inches covered with it.

6th. I found in horizontal sections, reddish-coloured membranes or expansions, as shown in Plate IX., fig. 6, giving off from one of their surfaces a number of elongated and blunt-pointed processes, not more than 1-200th of an inch long, and at their base about 1-1000th of an inch broad. And on vertical sections I noticed bodies similar to that shown in fig. 5 of the same plate. These differ greatly in size, and vary in colour from a bright yellow in thin sections to a bright or a dark-red in thicker ones. They present almost uniformly the appearance of reddish or yellow bands, bent so as to enclose irregular elongated spaces, which are always narrow and

sometimes of scarcely perceptible breadth. On their opposed edges the bands are smooth; on their exterior, they are almost uniformly tubercular or pilose. I believe that the various appearances presented by such sections as those from which figs. 5 and 6 were drawn, result from bodies of a similar kind, presenting themselves in different aspects in horizontal and vertical sections. That they are vegetable membranes I have no doubt, and I believe that they are the remains of more or less globular and membranous vesicles, studded externally with tubercles or hairs, and nearly smooth within. Are they spores? Whatever they are, they increase the similarity between the Torbanehill and other coals, for in the latter, in house coals especially, they are very abundant. Very good preparations of them may always be obtained from a thin layer of house coal below the Parrot of Bathvale, west of Boghead.

7th. Occasionally patches of dark-brown fragments are met with. They, I think, are such as appear frequently in small detached portions in the dark matter of the coal. One of the patches seems to be a portion of a vessel containing a fibre; if a fragment of a scalariform vessel, its colour is totally different from that generally existing in that tissue in the coal. Similar patches (as far as I can judge) occur quite commonly in other coals.

Sawdust and Powder.—When reduced to small fragments, as in the form of sawdust or powder, the Torbanehill coal separates in the position of the dark matter into rounded and flattened yellow masses, surrounded by a dark outline, or into groups of these masses. There are also numerous elongated fragments, yellow, reddish-brown, and dark-brown in colour, and rounded or angular in different instances. I believe all these appearances to be the result of an accumulation of vegetable membranes, cells, and fibres, which originally formed the mass. At any rate, whether vegetable or not, there is no essential difference in the microscopical appearances presented by small fragments of this coal and those of the Methill and Capledrae cannel coals.

Coke.—The coke of the Torbanehill coal is greyish, distinctly laminated, of the same bulk as the coal from which it is formed, and of but little use as fuel, from its containing so small a quantity of fixed carbon. When reduced to fragments, and examined microscopically, the coke of the upper layers of coal presents a number of irregularly rounded black masses, some of which have round or angular openings in them. The coke of the lower layers presents a greater number of elongated and angular fragments, such as might

be produced by woody fibres. These characters of the Torbanehill coal are such as belong to the coke of the Methill and Capledrae cannel coals. I feel satisfied that there are no essential differences between them, and that they are not distinguishable from each other by their microscopical characters.

Ash.—Neither in this coal, nor any other, is there a trace of vegetable structure in the ash, except where a very rare silicification has taken place. Care must be taken, however, that the mistake of confounding coke and the popular term ashes with the scientific word ash be not repeated. The ashes of coal (using the popular phrase) always contain vegetable structures unconsumed; but from the ash of coal, as spoken of by scientific men, all the organic matters have been driven off by careful combustion, and nothing but earthy matter remains.

It is important to distinguish the appearances first described, which are general in the bed of coal, with some of those last noticed, as only occurring occasionally in it. Whatever explanation of the structure and mode of formation of the bed may be adopted, it must be based on the appearances which are delineated in Plate VII., figs. 1 to 4, rather than upon those which are rare, selected from a number of specimens, and shown in some of the other figures. It is always desirable that the chemical composition of any body examined microscopically be taken into account; because where the microscope alone will not enable us to decide at once as to the nature of an object, the microscopical and chemical characters, taken together, will often do so. This is precisely such a case; for the conclusions which, I think, are to be drawn from the structure of this bed of coal, are in a most important manner corroborated and strengthened by the evidence of its nature which chemistry supplies.

Were we to arrange and classify the known coals chemically and histologically, it would be found that anthracite would take its position at one end of the scale and Torbanehill cannel coal at the other. Anthracite is almost pure carbon; Torbanehill contains less fixed carbon than any other coal. Anthracite is very difficult to ignite, and gives out scarcely any gas; Torbanehill coal burns like a candle, and yields 3,000 cubic feet of gas per ton more than any other known coal; its gas being also of greatly superior illuminating power to any other. Below the Torbanehill come the Wigan, Capledrae, and Lesmahago coals. In lightness in colour of the streak, Torbanehill stands highest, then come Methill, Rochsoles, and Capledrae.

Structurally, I place cannel coals at one end of the scale and anthracite at the other, common coals intervening. In anthracite it is very difficult to show vegetable structure of any kind; in common or house coal this can be done more easily; and in cannels most readily of all. The cannels I should arrange as follows:—Torbanehill, Bathvale, Barbachlaw, Wemyss, Methill, Capledrae, Lesmahago, Wigan, &c.

Space will not permit me to enter upon a detailed description of the appearances presented by other coals when examined microscopically. I may state, however, that those which the cannels present are essentially similar to those which I have described in the Torbanehill coal. I refer, for confirmation of this statement, to the figures of Methill, Wemyss, and Capledrae coals. The house coals differ more widely in structure from the cannels than these do amongst themselves; yet I think the essential features of the structural arrangements are nearly the same in all.

I know of nothing whatever to countenance an idea put forth in the paper before named,—that all our coals are formed of soniferous wood. On the other hand, I join geologists and naturalists in admitting the obvious and constant presence of fossil stigmariæ, lepidodendra, ferns, mosses, &c., as evidence that coal-beds were formed of such plants. I think the microscope affords the most conclusive evidence that the structural arrangements of coal are totally different from those of wood; and that it points to the formation of coal, especially of cannel coal, from a more or less fluid pulp, resulting from maceration and chemical changes taking place in large masses of vegetable tissues, such as are now going on in peat bogs, especially in those which are semi-fluid and quaking. Every one knows the effect produced upon the potato, apple, turnip, &c.—masses of vegetable cells—by boiling. The individual cells are isolated, and a soft pulp results. The anatomist knows that maceration produces precisely similar results on animal and vegetable tissues; and it is in this way that I believe the elements of the tissues of plants have been separated from each other, partially disintegrated, and re-arranged in a laminar form preparatory to their solidification into a mass of coal. Whether such coal contain an enormous percentage of fixed carbon, and give out scarcely any gas, as in anthracite; or have but a small quantity of fixed carbon, and give out a large quantity of gas, by the union of its hydrogen with other carbon, as in the Torbanehill coal, seems to depend upon the nature and amount of chemical change to which it has been subjected in its formation. In parts of

many coal-beds, no crystalline or other aggregation of earthy matter is detected by the microscope ; and yet chemistry determines the presence of a considerable amount per cent. of such matter. In such cases, I believe, the earthy matter has been added to the vegetable part in a state of solution, or fine molecular subdivision ; whilst, where in other instances crystals and earthy particles of considerable size occur, it is as plain that many of these have been deposited as such originally, as is likely to be the case in the instances in which beds of coal are formed in the beds of large rivers.

I will now endeavour to state very briefly the facts which I believe to have been made out in this investigation, with the conclusions which, I think, they warrant, as to the nature of the Torbanehill coal.

1st. That the whole seam is laminated—a sufficient explanation of its tendency to split horizontally, and of its slaty fracture.

2nd. That it abounds in fossil plants, especially Stigmariæ, which present well-preserved scalariform tissue on their surface, in whatever part of the bed they appear.

3rd. That the small angular facets, seen in different planes on every fractured surface, are produced by vegetable tissues, easily recognised under low powers of the microscope.

4th. That small blocks examined as opaque objects with low powers present rounded yellow spots on their upper and lower surfaces, and elongated yellow spots on their sides and ends, bounded by dark-brown matter—appearances which are produced by circular masses of yellow matter flattened vertically.

5th. That thin sections, made horizontally, show rounded yellow patches, often lobed ; but similar sections, made vertically, show yellow spots, elongated in the direction of the laminæ. These yellow spots are bounded by dark matter, in great part made up of fragments of vegetable fibre and membrane. The addition of heat drives off the yellow matter as gas, and leaves polygonal spaces, like the remains of vegetable cells, in the mass generally, and in some of the yellow bodies.

6th. That, besides the circular-flattened yellow bodies, there are much smaller polygonal and flattened bodies of the same colour, more uniform in diameter, sometimes with double walls, resembling vegetable cellular tissue.

7th. That other appearances, such as would be produced by masses of vegetable tissue sending off fibres or membranes into the spaces between the yellow bodies, to constitute their boundaries, occur here and there in the mass, confirming the

conclusions before drawn from the examination of the yellow bodies of the coal.

8th. That circular or angular-flattened bodies, or spherical ones, from 1-500th to 1-2000th of an inch in diameter, occur in considerable numbers in all sections of the coal, separate or in groups, and resemble free vegetable cells, as spores, pollen grains, &c.

Other bodies, of all sizes, up to the 1-20th of an inch, appearing more or less rounded and tubercular, or pilose, on one surface, as seen on horizontal sections, and linear and bent on vertical ones, appear here and there. Such appearances would be produced by membranous capsules or cells, tuberculated or pilose on the outside and smooth in their interior.

9th. That whatever opinions may be entertained as to the interpretation of the appearances presented by this coal, it is impossible, consistently with the facts, to deny that its sections present a remarkably regular arrangement of their parts, quite different on horizontal and vertical sections, and only capable of explanation by supposing it to have been the result of crystallisation, or of animal or vegetable organisation. That the coal is not a mass of crystals, is shown by the absence of the crystalline form, and, to some extent, by the fact that it does not polarise light. Neither its structure nor chemical composition offers the least countenance to the supposition that it is of animal origin; whilst every particular of its structure, and the fact that it is mainly composed of carbon, point to its being a mass of vegetable matter.

10th. The Torbanehill resembles other cannel coals in its geological position, its lamination, its variable thickness and value in different parts of the seam—in 65½ per cent. of it being carbon; in burning like a candle when lighted at a flame; in crackling in the fire; in containing every chemical ingredient found in other coals, and none but such as exist in them; in its great gas-giving power; in possessing a remarkably regular structure, differing widely on horizontal and vertical sections, similar in every essential feature to that existing in other coals, and only capable of explanation on the supposition that it is produced by vegetable tissues; and in being everywhere full of fossil plants, easily recognised by the naked eye.

11th. The Torbanehill differs from other cannel coals,—in its colour being lighter; in its streak being lighter in colour and dull; in its giving out far more gas than any other cannel; in containing less carbon and more ash than most other coals, and more hydrogen than any known coal; and in its being

tougher and more easily reduced to thin sections than other coals.

The differences it presents from other coals are, therefore, non-essential; not differences in kind, but in degree. The Torbanehill coal differs from other gas coals in being the best gas coal; it differs from other cannel coals in being the best cannel.

On the Enamel *and* Dentine *of the* Teeth. By T. H. Huxley, F.R.S.

The first part of the sixth volume of Siebold and Kölliker's 'Zeitschrift für Wissenschaftliche Zoologie,' published in July of the present year, contains a paper by M. Edouard Lent, 'On the Development of the Dentine and Enamel of the Teeth.' It could only be a source of gratification to me that any one should have been led fairly to investigate a subject, by the perusal of a paper of mine published in this Journal, even if his results were totally opposed to those at which I had arrived; and I do not think that, as a general rule, controversial writing is worth the paper it is printed on —assuredly, it is not worth the time it wastes. I should, therefore, have had nothing to reply to M. Lent's unfavourable expressions with regard to my labours, were it not for two circumstances. In the first place, M. Lent is a pupil of Professor Kölliker's, and appears to have worked under the eye of that distinguished investigator. Indeed, the paper is so completely sanctioned by Professor Kölliker, that I must regard him as responsible for it. And in the second place, owing, as I suppose, to M. Lent's inexperience as an author (though truly the superintendence of so practised a writer as Professor Kölliker should have obviated this difficulty), his paper is curiously inconsistent with itself, being in form a severe criticism and refutation—but, in fact, a confirmation —of the views I ventured to promulgate.

My paper was intended to establish two main points— 1. That there is no evidence that the dentine is formed by direct conversion of pre-existing elements of the pulp. 2. That the enamel is not developed externally to the so-called basement membrane, or membrana preformativa of the pulp, but internally to it; Nasmyth's membrane, which lies over the enamel, being in fact continuous with the membrana preformativa.

1. On this head, M. Lent adds no new fact or argument of any kind. He simply repeats and confirms the statement already made by Professor Kölliker—that minute gelatinous

processes may often be found passing from the surface of the pulp into the dentinal canals (a statement which no one denies), and then takes for granted Professor Kölliker's purely hypothetical interpretation of this fact—*i. e.*, that these processes are outgrowths of the "cells" of the surface of the pulp—an hypothesis which is not supported, so far as I am aware, by a shadow of direct evidence; and it is to be remembered that the *fact* is as well accounted for by my hypothesis as by any other.

So much for the formation of the dentinal tubules. With regard to the substance of the dentine, M. Lent does not seem to have seen much more than myself; for he says that "it is more probable—indeed certain" that the "grund-substanz" is an "*excretion of the cells and their processes.*" (p. 127.)

That is to say, M. Lent (*i. e.* Professor Kölliker) admits that there is no new evidence to be brought forward as to the formation of the dentine tubules, and that the substance of the dentine is formed as I have stated it to be. Truly, then, I do not see where the "*irrige ansicht*" with which I am charged lies.

At page 128 there is a very careless misstatement, which one might be disposed to overlook in a student, but which is utterly unpardonable in a production which has the advantage of Professor Kölliker's deliberate *imprimatur.*

"As regards Huxley's erroneous view as to the formation of the dentine, I will only briefly remark, that Huxley has been so unfortunate as to have seen the dentine from above only." (p. 128.)

This is truly astounding, considering that at page 160 of my paper I give particular directions how to obtain a profile view of the dentine in undisturbed connexion with the pulp; that figs. 3 and 4 are careful representations of such profile views; and that I lay particular stress upon the advantages to be derived from this mode of examination.

2. With regard to the development of the enamel, M. Lent (*i. e.* Professor Kölliker) affords a confirmation of my views; all the more valuable, as it is evidently most unwillingly wrung from him.

At page 129, M. Lent, after stating the ordinary theory of the development of the enamel, says: "This simple theory must, however, I believe, be given up, since Huxley has made a discovery whose truth I must confirm—a discovery which greatly enhances the difficulty of accounting for the formation of the enamel."

Again, at page 133: "From what has been said, it is pretty clear that the membrana preformativa, which may be detached

from the enamel in the fœtal tooth, subsequently becomes the so-called cuticle of the enamel, as, indeed, Huxley states."

Again, at page 130: "When, however, I tested Huxley's new statements, the matter appeared in quite a new light—the more as I could never succeed in discovering a trace of a nucleus in an enamel prism. Huxley, in fact, asserts that the enamel is formed beneath the membrana preformativa, and that the membrana preformativa and cuticle of the enamel are identical. In this point—as I have found by examining the fresh teeth of a new-born child and those of a six months' fœtus—he is about right."

I wish I could give the entire force of M. Lent's exquisite and polite acknowledgment of the truth of a fundamental fact for all further theories of dental development, but here is the original, for those who can appreciate it: "*Hiermit hat es seine Richtigkeit.*"

In this part of M. Lent's paper a second misstatement occurs, somewhat more gross, if possible, than that which I have already had occasion to notice.

At page 131 he says: "Of nuclei, such as Huxley describes and figures (in the membrana preformativa), I have seen nothing."

I have carefully re-examined my own paper, to see if I could find any excuse for a statement so utterly contrary to fact as this; and, for the sake of MM. Lent and Kölliker, I really almost regret to say I can find none whatever.

I invariably call the membrana preformativa a *structureless membrane.* I state that Nasmyth's membrane is "about 1-2500th to 1-1600th inch thick, perfectly clear and transparent, and, under a high power, exhibits innumerable little ridges upon its outer surface, which bound spaces sometimes oval and sometimes quadrangular, and about 1-5000th of an inch in diameter." And I go on to say that this membrane is nothing but the altered structureless membrana preformativa. I am equally at a loss to discover any figures of these "nuclei;" though it is possible that in consequence of the reticulation not having been carried evenly all over Nasmyth's membrane in fig. 2, a very careless person might misunderstand the figure—the text, however, would at once correct this misapprehension.

I have neither space nor inclination to follow M. Lent further; as what has been said proves abundantly the only point worth discussing at all: viz., that the two main facts asserted in my paper are admitted to be *bonâ fide* additions to our knowledge; in fact, one might almost fancy M. Kölliker addressing to M. Lent, Balak's famous reproach to Balaam—"I

called upon thee to curse this people, and, lo! thou hast blessed them these many times."

So far as I am personally concerned, I care little enough about being absorbed, after Professor Kölliker's ordinary fashion, in the next edition of the 'Mikroskopische Anatomie,' where we shall, I doubt not, read, "I and Huxley have made out that the enamel is formed under the membrana preformativa," &c., &c. But I think that Professor Kölliker will do well to reflect whether he is likely to increase his most deservedly high reputation, by encouraging in a student a disingenuousness of which he himself, I hope, would be heartily ashamed.

I may add, in conclusion, that there are, I believe, two very good minor grounds of cavil in my paper. One is at page 159, where I state incidentally that Professor Kölliker does not mention Nasmyth's discovery in his 'Mikroskopische Anatomie'—an error for which I cannot account, and for which I can only apologise, as a complete oversight. The other is the description of the cement of the calf's tooth at page 162; in which, a subsequent examination has led me to think there are errors of interpretation. I have had no leisure to re-examine this point, and I recommend it to MM. Lent and Kölliker, if, as it would seem, they have some unaccountable source of satisfaction in finding me wrong—a thing I do myself, quite without satisfaction, every day.

On the Determination *of* Species *in the* Diatomaceæ. By the Rev. Wm. Smith, F.L.S., Professor of Natural History, Queen's College, Cork.

It has been said, that "Synonymy is the opprobrium of Science," and not without reason; for synonymy owes its existence to imperfect knowledge, imperfect observation, or imperfect judgment.

Still, as few authors can be required to possess a thorough acquaintance with the literature of science, and still fewer can be supposed to exercise perfect accuracy of eye and unerring powers of judgment, synonymy is, to a certain extent, unavoidable.

Facts or circumstances first received by one student, will be again rediscovered by a subsequent observer ignorant of the former record, and registered as new; and known properties or characters, hitherto regarded as of transient or inferior importance, will be seized upon by a new writer, and made the basis of important distinctions.

The multiplication of synonyms may, however, be restrained within moderate limits, if the scientific observer will exercise due caution in the creation of new names, carefully abstaining from designating the subjects of his study, until he has made himself, as far as possible, acquainted with the labours of his predecessors in the same field; and until he has acquired, from a wide examination of allied forms, in every stage and condition of growth, sound and invariable rules, by which to determine how far certain differences are to be regarded as specific distinctions, or as accidental or transitional variations.

In a branch of study to which many are attracted by the excitement of novelty, and the laudable desire of discovery, there is some danger that these important cautions may be overlooked or neglected; and if the student of larger experience can, by his remonstrance, curb the impetuosity of such inquirers or impose upon them safe and certain rules of observation and discrimination, so that the new science shall not be burthened with an unnecessarily extended nomenclature, he will be doing some good service, and saving future observers much painful and unprofitable labour.

It is with this view that I venture to make a few remarks upon the discrimination of species in the Diatomaceæ, a department of nature now inviting and receiving much attention, and in which it is probable many real and presumed discoveries, as regards new forms, will rapidly be made by the host of observers who have been attracted to the study.

Several years of close observation of these organisms have, I believe, enabled me to clear up some of the more difficult points in their structure and growth, and led me gradually to the adoption of certain views, as to specific characters in their regard, that it may be of some utility at the present moment, and in anticipation of the contents of the second volume of my Synopsis, to lay before the public.

The ordinary Diatomaceous frustule seems to owe its reproduction to the protoplasmic contents of the sporangial frustule, formed by the process of conjugation. These *sporangia*, like the seeds of higher plants, often remain for a long period dormant, and are borne about by currents, or become embedded in the mud of the waters in which they have been produced, until the circumstances necessary to their development concur to call them into activity. At such times their silicious epiderms open to permit the escape of the contained endochrome, which is resolved into a myriad of embryonic frustules; these either remain free, or surround themselves with mucus, forming a pellicle, or stratum, and in a definite,

but unascertained period, reach the mature form of the ordinary frustule.

The farther growth of the individual cell seems now to be almost entirely arrested by the formation of the silicious valves, and the multiplication of these forms, of the size thus reached, goes on with inconceivable rapidity, by means of self-division.

The size of the mature frustule before self-division commences, is, however, dependent upon the idiosyncracy of the embryo, or upon the circumstances in which its embryonic growth takes place; consequently a very conspicuous diversity in their relative magnitudes may be usually noticed in any large aggregation of individuals, or in the same species collected in different localities.

It may also be easily conceived, that while a typical outline of its cell must be the characteristic of a certain species, such outline may to some extent be modified by the accidental circumstances which surround the embryo during its earlier growth and development. A lanceolate form may become linear, elliptical, or even somewhat oval, by the pressure of surrounding cells; and acute ends may be transformed into obtuse or rounded extremities.

Those who understand the process of self-division will see here a sufficient reason for the occurrence of multitudes of frustules, deviating from the normal form, or even for the existence of myriads, at one spot, all having a form different from the type, the single embryo from which they have all sprung by self-division (which process stereotypes the shape with which it commences), having from some accidental circumstances become modified in its outline.

It follows then, from these considerations, that neither size nor outline are sufficient to enable the observer to determine the species of a Diatomaceous frustule. If he has the means of comparing specimens in sufficient numbers, and from various localities, he may fix with tolerable certainty upon the magnitude and form which may be regarded as the average and type of the species; but without such opportunities, a reliance upon such characters will inevitably lead to the undue multiplication of species, and to a confused and erroneous nomenclature.

There are three circumstances which seem to me to be of essential importance as regards the specific character of the diatom: first, the structure of the valve; second, the habitat; and third, the arrangement of the endochrome in the living frustule. I have placed the structure of the valve first in order, because this is a feature which can be ascertained in

every condition under which these forms present themselves, whether in a living, dried, or fossil state; and also because it appears to me to be the most constant and obvious character of such organisms. These varieties of structure arise from the modes in which the silex combines with the cellulose of the epiderm, and this combination seems to follow certain and invariable laws which are subject to no derangement from the external circumstances in which the growth of the embryo may take place. The structure of the valve reveals itself in the striation, in the character of the striation, may therefore be found a good specific distinction. Whether the striæ are costate or moniliform, parallel or radiate, reach the median line, or are absent from a greater or lesser portion of the valvular surface, and numerous other features which may exist, separately or in combination,—these appear to me to be circumstances which the observer who wishes to discriminate and determine the species should most carefully regard. The relative distances of the striæ, and their greater or less distinctness, (which are not, by-the-bye, always identical characteristics,) are also features which may be safely and properly recorded; but I am not certain that these features may not, to a slight extent, be modified by localities and age, and am disposed to believe that they are certain guides only when we have made allowance for these conditions; and that, while they are constant in frustules originally from the same embryo, they may slightly vary in those which owe their birth to different embryonic cells.

In describing a species, we should therefore carefully note the *character of the striation*, and state as nearly as possible the *average* number of the striæ. The dry valve will frequently aid in such determinations, the presence and extent of the striation being usually indicated by the colour of the valvular surface, even when the power employed fails to detect the striæ themselves; the differences in colour not unfrequently answering to the relative distances, or distinctness of the markings.

Next to the striation of the valve I have placed *locality*, as a means of arriving at a specific distinction. Where forms are closely allied, this circumstance will often aid in their discrimination; for not only do I regard it as established that no fresh-water species will live in a marine habitat, nor a marine species flourish under the predominating influences of springs and rivers; but I believe that certain species are far more special in their tastes, some selecting mountain torrents, others clear and still waters; some rejoicing in the deltas of rivers, and others fixing their habitations in boggy pools, or alpine

lakes; some being littoral, and others only found in the deeper parts of the ocean. When structural differences are not obvious, such circumstances as these will not unfrequently assist the inquirer to resolve his doubts, and assign to a form, a position and a name.

And lastly, *the arrangement of the endochrome*, in the living frustule, will be found to confer a specific character, one far more certain than habitat; but from its being less easily, or less frequently within the observer's notice, not so practical in its application.

Those who have the means of examining the living cell are well aware that there is in every species a distinct feature conferred by the position of the cell contents; in one the endochrome is closely applied to the inner surface of the valve; in another aggregated in the centre of the frustule; sometimes sparingly diffused throughout the interior; or again exhibiting a radiate or stellate arrangement; at all times having one or several oily globules, which occupy in different species different positions, but are constant in number and situation in the same species.

These characters are not always within reach of the ordinary microscopist, who contents himself with an examination of the silicious valve in a dried or prepared condition; but the systematist, who desires to define and discriminate, will not neglect these features, and will hesitate to decide between closely allied forms until he has the means of scrutinizing the living frustules, and noting the differences which exist in the position and arrangement of their cell contents.

It will be apparent from these remarks, that the determination of species in the Diatomaceæ is at all times a task of difficulty, and that this difficulty is much enhanced when the observer does not enjoy the opportunity of examining these organisms in their living state, or has only prepared or fossil specimens, within the reach of his observations.

In such a case the student is disposed to rely too much upon the obvious characteristics of size and form; now it often requires a careful examination of specimens collected in various localities, and in every condition of growth, to enable the observer to fix upon the size which may be regarded as an average, or upon the outline which ought to be accepted as typical of the species.

To adopt as specific a shape or size that occurs in but one gathering, whether the individuals therein be more or less numerous, is, I feel persuaded, a most fallacious method of procedure. And although the striation is at all times an important guide, it often happens that this feature is so nearly

alike in allied species of the simpler forms, such as *Cocconema*, *Cymbella* and *Navicula*, that our determination must be influenced by less important considerations, and the habitat, outline, and arrangement of the cell-contents, all require to be brought under review before we should feel justified in constituting a species.

It may be said that, to describe and figure every *variety* that presents itself to our notice, will aid future observers in the study and determination of these forms. If practicable, this course might be a desirable one; but this is no more possible in Diatoms than the representation of every leaf, which varies however slightly in form and size from another, would be possible in our description of a forest-tree; and the elevating of such diversities into specific distinctions, and the conferring a distinct name upon each aberrant individual, seems to me a course more likely to confuse and to embarrass than to lead to a clear arrangement or satisfactory system. Besides, it overloads a scientific arrangement with a cumbrous nomenclature, which unduly taxes the time and patience of future observers to simplify or remove.

It is, therefore, far better to expend our labour in endeavouring to combine, unite and harmonize the interminable varieties of nature, and thus in a few brief and simple terms to embrace a number of seemingly different, but truly identical, specific forms, than to encumber science with a phraseology which alarms the general inquirer, and enhances the labour of the more studious observer.

TRANSLATIONS.

On the Structure *and* Systematic Position *of the* Rotifera.

(Abstract of Dr. F. Leydig's observations.)

In the 'Zeitschrift f. Wissenschaftliche Zoologie' of Siebold and Kölliker, Vol. VI. Part 1, is a valuable Memoir by Dr. F. Leydig, upon the structure and systematic position of the Rotifera; illustrated with four plates of most elaborate and beautiful figures, displaying the structure of, or other particulars relative to *Stephanoceros Eichhornii*, *Floscularia appendiculata*, *Tubicolaria najas*, *Pterodina patina*, *Polyarthra platyptera*, *Scaridium longicaudum*, *Notommata Sieboldii*, *N. centrura*, *Eosphora najas*, *N. aurita*, *N. tardigrada*, *Euchlanis triquetra*, *Stephanops lamellaris*, *Ascomorpha germanica*, *Notommata myrmeleo*, *Euchlanis triquetra*, *Noteus quadricornis*, *Brachionus Bakeri*, *B. rubens*, *Euchlanis unisetata*, &c.

The first part of the paper embraces descriptions of the various species observed by the author, as occurring in the neighbourhood of Würzburg; to which succeeds an exposition of the condition of organization of the class in general; and the last part of the essay is devoted to a determination of the systematic position of the Rotifera.

The new species described by the author are—

Floscularia appendiculata.
Notommata Sieboldii.
„ *tardigrada.*
Ascophora germanica.

The second part of the paper, or that embracing the description of the structure of the Rotifera in general, though too long for insertion in this Journal, is a most valuable contribution to our knowledge of the structure, both histological and general, of those creatures; and must, of necessity, be studied by all who pay attention to the subject.

Though not agreeing with Dr. Leydig in his views respecting the alliance of the Rotifera with the Crustacea, believing with Mr. Huxley that they are more closely related to the Annelids, we have thought that the Chapter on the *Systematic position* of the Rotifera might be interesting to those who wish to see both sides of the question; and the more especially as it contains many interesting and important observations on the subject to which it is devoted.

We have also appended the author's *Systematic arrangement* of the Rotifera.

ON THE SYSTEMATIC POSITION OF THE ROTIFERA.

Formerly placed among the Infusoria, of which they formed the second class in the classification of Ehrenberg, it has been latterly admitted by all systematic writers, that the ROTIFERA possess nothing in common with the animals truly belonging to that class, or the *polygastrica* of the Berlin Professor: but that, in respect of their complex structure, they represent a higher type of organization. Opinions, however, are still divided on the question, whether the *Rotifera*, as Burmeister believes, belong to the *Crustacea*, or should be referred to the Annelids, in accordance with the opinion of Wiegmann, Wagner, Milne-Edwards, Berthold, V. Siebold, and others.

If the truth were always with the majority, we should undoubtedly be obliged to place the Rotifera in the class of Annelida; but I believe, nevertheless, that Burmeister is in the right, though opposed to all the other observers above named. *I also conceive that the Rotifera are much more closely allied to the Crustacea than to the worms;* and, by comparing the conditions of organization of the two classes, shall venture to support this view in the following observations.

It may first be mentioned, that so far back as 1824 Nitzsch asserted, that the Rotifera resembled the Entromostraca; and, what certainly deserves attention, Ehrenberg himself, though placing them with the Infusoria, frequently remarks upon their resemblance to the Crustacea and Entomostraca; thus, in his great work, p. 410, he says, that the "spicules, beards, and setæ" of many species might be compared with the arms of the *Daphniæ;* and in p. 411 he remarks, that many Rotifera carry about their eggs attached to them, "like the Crustacea;" and speaks to the same effect in many other places. Dujardin also notices similar resemblances with *Cyclops*, *Cypris*, &c.; as, for instance, at pp. 574 and 575 of his work.

If the systematic position of the Rotifera were to be determined mainly from their *external figure*, the result would certainly be more in favour of the Crustacean than of the Annelid type. No annelid has articulated motile organs, whilst, on the contrary, the possession of such organs in a perfectly symmetrical form is a fundamental character of the Arthropoda. The majority of the Rotifera are not furnished, it is true, with a pair of feet, although they have a single annulated, or jointed foot, containing no part of the viscera, but which is applied solely to the purpose of locomotion. Furthermore, if the rest of the conformation of the body be regarded, it is obvious at once that a *Euchlanis*, *Salpina*, and, in short, all whose cuticle has acquired the hardness of a *lorica*, are more closely approximated to a crustacean than to a worm. For in the whole vermiform division I am unacquainted with any form whose cuticle is indurated to the same extent.

The muscular structure also approximates, in many Rotifera, more nearly to the Arthropoda than to the Annelids. In no animal of the latter class have genuine transversely striped muscles hitherto been seen; that is to say, muscles whose contents are divided into minute quadrangular particles, like those of the muscles of vertebrate animals.

That the motions of the body of many species recall in a striking manner those of the Crustaceans has already been noticed.

If the *nervous system* be considered, its similarity with that of the

lowest Crustaceans cannot escape recognition. In the Rotifera it consists simply of a cerebral ganglion, with branches radiating from it; there is no abdominal chord, nor any chain of ganglia. But is the nervous system of the Lophyropoda more developed? In the Daphniæ, even, we are acquainted only with a cerebral ganglion and nerves proceeding from it; and, consequently, know of no grounds upon which to establish the law, that a central nervous system, consisting of a ganglionic ring surrounding the pharynx, and of a chain of abdominal ganglia proceeding from it, belongs to the Crustacea as a fundamental character.

Moreover, the manner in which the sensitive nerves terminate peripherally in the Rotifera corresponds precisely with what I have described, regarding this point, in the Crustacea and Insecta; and nothing like which is at present known to exist in the class "Vermes." Lastly, I shall not repeat at length, but merely remark, that the eye-spots apparent on the nervous centre of the Rotifera approximate most closely to the similar structures of the Crustacea, as Ehrenberg has not failed to indicate.

The disposition and texture of the *alimentary canal*, in an inquiry into the systematic position of the Rotifera, afford no decisive evidence in favour of one view or the other, since many Annelids also have a complex horny masticatory apparatus; still, with respect to this I would remark, that the masticatory apparatus of young *Daphniœ* (I have examined, for this object, the deep yellow-red young of a very large species, *Daphnia maxima ?*) presents a pretty close similarity with that of many Rotifers, inasmuch as the two opposed jaws expand into a plate, which is toothed with numerous transverse ridges, exactly like the corresponding plate in *Lacinularia*.

The glandular lobate appendages placed upon the stomach in the Cirripeds, which have been explained as "salivary glands," might, perhaps, be regarded as analogues of the ventricular glands of the Rotifera. Similar organs, however, also exist in many of the dorsibranchiate Annelids; many Annelids also, like many of the lower Crustaceans, are alike in the circumstance that the liver is represented simply by large cells, with peculiar contents, situated in the wall of the stomach or intestine. Should any one find an objection to the arthropodous type in the deficiency of an intestine in some Rotifers (*Notommata anglica*, *N. Sieboldii*, &c.), he may recall the neuropterous larva of *Myrmeleon*, in which, as is well known, the fæces are also discharged by the mouth; the *rectum* being transformed into a spinning organ. But with respect to the intestinal tract of many Rotifers (as *Euchlanis*, *Stephanoceros*, &c.), what especially recalls the condition of that part in the lower Crustacea, is its peculiar bell-like movement, which is precisely similar to that with which we are acquainted in the intestine of certain parasitic Crustaceans (*Achthenes*, *Tracheliastes*, &c.)

As to the substance which I have pronounced to be a *urinary secretion*, the close relations which obtain, with respect to it, between the Rotifers and the *larva* of *Cyclops*, cannot fail to be recognised; whilst anything allied to it is wholly wanting in the Annelids.

Lastly, the anatomical and physiological phenomena relating to the *sexual life* speak loudly enough in favour of the proposition that the Rotifers should be ranked with the Crustacea. I would not lay much stress upon the circumstance that they produce two kinds of *ova*,—the so-termed "summer" and "winter-eggs" (the latter in *Triarthra*, in the structure of their shell present much similarity with the ephippian eggs of *Daphnia*), or that many species carry their ova about with them; for, as regards these particulars, the genus *Clepsine* among the Annelids might be named as one in which the same thing takes place. The coloured oil-globules

also, met with in the *vitellus* of many Rotifers, and indicative of a Crustacean type, may be left out of consideration. But of greater importance, perhaps, is the striking analogy existing between the male Rotifers—which in a certain sense may be said to be aborted—and those of many Crustaceans. Who will not remember the diminutive, male parasitic Crustaceans, which Nordmann discovered on the female individuals of *Achtheres*, *Brachiella*, *Chondracanthus*, and *Anchorella*, and Kröyer in other Lernæopoda and Lerneæ?

And the reason that we are only just beginning to become acquainted with separate males of Rotifers is probably due to the same circumstances,—appearance at a certain time of year, diversity of figure from that of the female—as those owing to which we have not yet discovered the males, for instance, of *Ergasilus*, *Polyphemus*, *Limnadia*, *Apus*, &c.

If the *development* also of these creatures be regarded, it will be found in favour of our view; for, with respect to several species, it has been shown that the young, at its liberation from the *ovum*, has not got the form of the adult animal, and, consequently, must undergo a metamorphosis. And is not the subsequent diminution, and even complete disappearance of the eyes, which exist in the young condition of the animal, a farther indication of an approach towards certain Crustacean forms?

Whilst the structural conditions hitherto mentioned more or less powerfully support the view of the Crustacean nature of the Rotifera, they are, on the other hand, separated from the Crustaceans by the condition of the respiratory organs and the presence of vibratile cilia, and approximated to the Annelids; but in both these respects they equally approach the Echinodermata; for, as has been said above, the proper vibratile organs of *Synapta digitata* appear to me to be structures equivalent to the "vibratile organ" of the Rotifer.

But in the determination of the systematic position of an animal, the question must depend, as it seems to me, upon the fact, whether the sum of the resemblances is greater than that of the differences, as respects the animal groups with which the animal might be supposed to be associated. In applying this law to the subject under discussion, we find that the number of conditions allying the Rotifers with the Crustaceans far exceeds that of the properties possessed by them *not* in common with the Crustacea. I consequently regard it as fully justifiable to rank the *Rotifera as a special order of Crustacea*, and propose, from the distinctive character exhibited in them, to denominate them "*ciliated Crustaceans*" (Wimperkräbse). They necessarily stand at the commencement of the Crustacean class; since, in the structure of their respiratory organs, they continue to be allied with the Annelids. Huxley (l. c.) has regarded them as Annelids possessing permanently the form of the Echinoderm-larva, and has expressed this comparison in diagrammatic figures (l. c., Plate III.), in which he places *Lacinularia* opposite an Annelid larva, *Melicerta* opposite to that of *Asterias*, *Philodina* to that of *Holothuria*, *Brachionus* to the larva of *Sipunculus*, and, lastly, *Stephanoceros* to the larva of *Echinus*. Although the ingenuity of this attempt must be admitted, still I am unable to adopt the view of the English observer, but am compelled, from the considerations above detailed, to declare myself an adherent to Burmeister's view, as the only one agreeing with my own.

CLASSIFICATION OF THE *CILIOCRUSTACEA*.

It is obvious that the arrangement of the Ciliocrustaceans, or Rotifers, as proposed by Ehrenberg, must be changed, inasmuch as the principle

upon which it is founded rests upon an erroneous basis. *Polytrocha* and *Zygotrocha* do not exist, nor is it at all admissible, that in many species the gelatinous envelope should be termed a *lorica*, whilst in others the hardened cuticle should be understood under the same term. Similar criticisms upon Ehrenberg's system have before been made from other quarters, although no one, except Dujardin, has proposed a new arrangement. The latter naturalist has endeavoured to arrange the Rotifers by taking the mode in which the movements are effected as the basis of his system; in accordance with which he has erected the following orders:—

Ordre I.—Systolides fixés par un pedicule.
1. Famille. *Flosculariens.*
2. Famille. *Melicertiens.*

Ordre II.—Systolides nageurs.
3. Famille. *Brachioniens.*
4. Famille. *Furculariens.*
5. Famille. *Albertiens.*

Ordre III.—Systolides alternativement rampants et nageants.
6. Famille. *Rotifères.*

Ordre IV.—Systolides marcheurs.
7. Famille. *Tardigrades.*

With the exception of the *Tardigrada*, I decidedly prefer Dujardin's system to that of Ehrenberg, founded as it is upon a correct principle of arrangement, and recommended by its simplicity.

Probably, however, the Rotifera may be arranged according to their forms; whether they are cylindrico-conical, or sacciform, or compressed, together with which, as further characters, the condition, presence, or absence of the foot, may be employed. Proceeding upon this idea, I would venture to propose something like the following arrangement.

Ciliocrustacea.

Animals with a jointed body and a ciliary apparatus at the cephalic extremity. The nervous system consisting of a cerebral ganglion, and filaments radiating from it. Digestive and respiratory systems much developed. No heart or blood-vessels. Sexes separate. The female produces "Summer" and "Winter-ova." Many undergoing metamorphosis.

A. Figure between clavate and cylindrical.

I. With elongated, transversely-ringed, attached foot.

1. Floscularia *proboscidea*, Ehrenberg; *ornata*, Ehr.; *appendiculata*, n. s.
2. Stephanoceros *Eichhornii*, Ehr.; *glacialis*, Perty.
3. Œcistes *crystallinus*, Ehr.
4. Conochilus *volvox*, Ehr.
5. Lacinularia *socialis*, Ehr.
6. Limnias *ceratophylli*, Schrank.
7. Tubicolaria *najas*, Ehr.
8. Melicerta *ringens*, Schrank.

The genera *Ptygura* and *Glenophora*, Ehr., which, according to their forms, would also belong to this division, do not appear to me to be fully-grown animals at all, but undeveloped forms; and it is not improbable, as Ehrenberg himself was at one time disposed to believe, that *Ptygura* is the young of *Melicerta ringens*.

The genus *Cyphonantes*, instituted by Ehrenberg upon two animalcules found in water from the Baltic, is certainly not a Cilio-crustacean at all. From the figure alone, and still more from the description, it is obvious that this creature has no alliance whatever with a Rotifer, except in the ciliary movement. It is probably the *larva* of some marine animal, and I should suppose that of an acephalous mollusc.

II. With elongated, jointed foot, retractile, like a telescope.

1. CALLIDINA *elegans*, Ehr.; *var. rosea*, Perty; *cornuta*, Perty.
2. HYDRIAS *cornigera*, Ehr.
3. TYPHLINA *viridis*, Ehr.
4. ROTIFER *vulgaris*, *citrinus*, *erythræus*, *macrurus*, *tardus*, Ehr.
5. ACTINURUS *neptunius*, Ehr.
6. MONOLABIS *conica*, Ehr.
7. PHILODINA *erythrophthalma*, *roseola*, *macrostyla*, *citrina*, *aculeata*, *megalotrocha*, Ehr.

III. With elongated, jointed, non-retractile foot.

1. SCARIDIUM *longicaudum*, Ehr.
2. DINOCHARIS *Pocillum*, *tetractis*, *paupera*, Ehr.

IV. With a short foot and long pedal forceps.

1. NOTOMMATA (?) *tigris*, *longiseta*, Ehr.
2. MONOCERCA *rattus*, *bicornis*, *valga*, Ehr.
3. FURCULARIA *gibba*, *Forficula*, *gracilis*, Ehr.
4. MICRODON *clavus*, Ehr.

The genus *Microdon*, which I have never seen, would appear, from the observations respecting it communicated by Ehrenberg and Perty, to be worth attention. I imagine it may represent a male Cilio-crustacean.

V. With short foot and pedal forceps, which are of equal length with, or somewhat shorter or longer than the foot.

1. HYDATINA *senta*, *brachydactyla*, Ehr.
2. PLEUROTROCHA *gibba*, *constricta*, *leptura*, Ehr.
3. FURCULARIA *Rheinhartii*, Ehr. (probably not a *Furcularia*, but a *Notommata*).
4. NOTOMMATA *tuba*, *petromyzon*, *saccigera*, *copeus*, *centrura*, *brachyota*, *collaris*, *najas*, *aurita*, *gibba*, *ausata*, *decipiens*, *felis*, *parasita*, *tripus*, Ehr.; *tardigrada*, n. sp.; *vermicularis*, Duj.; *roseola*, *onisciformis*, Perty.
5. LINDIA *torulosa*, Duj.
6. SYNCHÆTA *pectinata*, *baltica*, *oblonga*, *tremula*, Ehr.
7. DIGLENA *grandis*, *forcipata*, *aurita*, *catellina*, *conara*, *capitata*, *caudata*, Ehr.
8. RATTALUS *lunaris*, Ehr.
9. DISTEMMA *forficula*, *setigerum*, *marinum*, *forcipatum*, Ehr.
10. TRIOPHTHALMUS *dorsualis*, Ehr.
11. EOSPORA *najas*, *digitata*, *elongata*, Ehr.
12. CYCLOGENA *lupus*, *elegans*, Ehr.
13. THEORUS *vernalis*, *uncinatus*, Ehr.

Ehrenberg's genus, *Enteroplea hydatina*, is the male of *Hydatina senta*; and his *Notommata granularis* stands in the same relation to *Notommata brachionus*, which latter genus, however, is placed far more correctly under the genus *Brachionus* than under *Notommata*. *Diglena granularis*, Weisse, lastly, is the male of *D. catellina*, Ehr.

The genus *Lindia*, Duj., is said to be without *cilia* on the head, which I much doubt.

VI. Without foot.

1. Albertia.

Includes the *A. vermiculus*, found by Dujardin in the abdominal cavity of the Earthworm, and in the intestine of the Limacina; and *A. crystallina*, discovered by Schultze in the intestine of *Nais littoralis*.

I have long ago noticed a similar *Albertia* in the intestine of *Nais elinguis*. On comparing the drawings I then made with the figures given by Schultze, I perceive the closest correspondence with his fig. 13. (Beiträge zur Naturgesch d. Turbellarien, Taf VII. &c.) So that it may probably be the same species.

B. Figure sacciform.

I. Foot short.

1. Notommata *clavalata*, *myrmeleo*, *syrinx*, Ehr.
2. Diglena *lacustris*, Ehr.

II. Foot absent.

1. Notommata *anglica*, Dalrymple; *Sieboldii*, n. sp.
2. Polyarthra *platyptera*, Ehr.
3. Triarthra *longiseta*, *mystacina*, Ehr.
4. Ascomorpha *helvetica*, Perty; *germanica*, n. sp.

C. Figure compressed.

a. Depressed from above downwards.

I. With a foot.

1. Euchlanis *triquetra*, *Hornemanni*, *luna*, *macrura*, *dilatata*, *lynceus*, Ehr.; *unisetata*, n. sp.; *bicarinata*, n. sp. (*E. bicarinata*, Perty, I consider a *Salpina*).
2. Lepadella *ovalis*, *emarginata*, *salpina*, Ehr.
3. Monostyla *cornuta*, *quadridentata*, *lunaris*, *carinata*, Ehr.
4. Metopidia *lepadella*, *acuminata*, *triptera*, Ehr.
5. Stephanops *lamellaris*, *muticus*, *cirratus*, Ehr. (Dujardin declares that *St. muticus* is *Lepadella ovalis*).
6. Squamella *bractea*, *oblonga*, Ehr.
7. Notogonia *Ehrenbergii*, Perty.
8. Noteus *quadricornis*, Ehr.
9. Brachionus *pala*, *amphiceros*, *urceolaris*, *rubeus*, *Mülleri*, *brevispinis*, *Bakeri*, *polyacanthus*, *militaris*, Ehr.
10. Pterodina *patina*, *elliptica*, *clypeata*, Ehr.

II. Foot absent.

1. Anurea *quadridentata*, *squamula*, *falculata*, *curvicornis*, *biremis*, *striata*, *inermis*, *acuminata*, *foliacea*, *stipitata*, *testudo*, *serrulata*, *aculeata*, *valga*, Ehr.

β. Laterally compressed.

1. Salpina *mucronata*, *spinigera*, *ventralis*, *redunca*, *brevispina*, *bicarinata*, Ehr.
2. Mastigocerca *carinata*, Ehr.
3. Monura *colurus*, *dulcis*, Ehr.
4. Colurus *uncinatus*, *bicuspidatus*, *caudatus*, *deflexus*, Ehr.

REVIEWS.

Ueber den Organismus der Polythalamien (Foraminiferen), nebst Bemerkungen über die Rhizopoden in Allgemeinen. Von Max Sigmund Schultze, Griefswald. Mit vii. color. Kupperft. (On the Organization of the Polythalamia (Foraminifera), together with Remarks on the Rhizopoda in general.) Leipzig, 1854: pp. 68; with 7 coloured Plates.

Naturalists in general, but especially those whose attention is more particularly given to microscopic research, will at length be gratified with the appearance of a satisfactory work upon the Rhizopoda. And the more so as it would appear to be but the precursor of further labours in the same field by the author, who has already proved himself a most able, assiduous and conscientious observer, by his valuable memoir on the Turbellariæ, published in the Wurzburg Transactions, and by other papers, in Müller's Archiv. and elsewhere, on different subjects of natural history.

He intends apparently to devote himself particularly to the study of the Rhizopoda, and has made large collections of recent and fossil forms for this purpose. From this source, therefore, in addition to the promised work on British Foraminifera to be published by the Ray Society, and upon which Drs. Carpenter and Williamson are, we believe, now at work, we may expect very great additions to our knowledge of this, as yet, obscure and confusing class of creatures; the study of whose remains, however, is of the utmost importance, particularly in a geological point of view, from their vast range in both time and space throughout nearly all geological formations. And their importance appears to be much enhanced by the consideration of the astounding fact recorded by Professor Bailey, and noticed in the last number of this Journal (p. 89), with respect to deep soundings in the Atlantic, which, it is believed, are the deepest ever submitted to microscopic investigation. The results of this examination go to prove that the bottom of the North Atlantic Ocean, from a depth of 60 fathoms to that of more than two miles, is literally nothing but a mass of microscopic shells; which it is shown must have *lived* at the depth where they are found, and not in the superincumbent water—these shells are almost all those of Foraminifera.

The present work of Dr. Schultze, which, as we have ob-

served, is only the commencement of his labours in this department, is limited to the object of communicating faithful observations with respect to the structure and vital phenomena of the testaceous marine Rhizopoda, and to bring our knowledge of them, so far as possible, *au niveau* with the rapid advances which have of late years been made in that of the other Protozoa.

One obstacle experienced by all who have addressed themselves to the study of the soft part of the Rhizopoda, and which has probably altogether deterred many from it, has arisen from the difficulty of procuring those creatures in the living or well preserved state. Professor Schultze mentions, as an encouragement to the study, that he found no difficulty in bringing numbers of *Polystomella strigilata*, several *Gromiæ*, *Rotaliæ*, and *Miliolidæ*, from Venice and Ancona to Griefswald; nor in keeping them alive for more than twelve months, in as useful a condition for observation as on the first day. He had, moreover, partially changed the sea-water but once during the whole time. The water, however, contained living *Ulvæ*. He has also found that specimens from abroad, preserved in spirits of wine, served extremely well for the purpose of studying the soft parts.

Owing to the general similarity which exists apparently throughout the rhizopodous class in the intimate structure of the soft part, their systematic arrangement can only be founded upon the shells, which exhibit an astonishing diversity of form. Out of these forms it would appear, that the labours of various naturalists in the last 100 years have made known nearly 2,000 species of recent and fossil Foraminifera; and although the observations of Dr. Carpenter tend to show the probability that very many of these supposed species are merely varieties, still the number is sufficiently great to prove the importance and interesting nature of the subject. Dr. Schultze remarks upon the difficulties attending the study of the Rhizopoda, and insists very properly upon the necessity of viewing them in all positions, and under different modes of illumination and of preparation, in order to arrive at a due conception of their conformation.

The work commences with a copious literature of the subject, and then, after a short historical introduction, proceeds to general considerations on the structure and vital phenomena of the Rhizopoda, commencing with a description of the hard part, or shell, followed by that of the soft tissue contained therein. An account is then given of their nutrition, reproduction (confessedly imperfect), and growth; to which succeed observations on the nature of the Polythalamia, as

individuals or as colonies, and on the occurrence and the collecting of living marine Rhizopoda.

To this part of the work are added remarks upon the classification of the Rhizopoda, including a tabulated view of the families and genera, and the description, with beautiful figures, of the species observed by the author in the living state, of which we subjoin a list:—

Gromia.	*Rotalia.*	*Textilaria.*
Lagynis.	*Rosalina.*	*Polystomella.*
Squamulina.	*Polymorphina.*	*Acervulina.*
Miliola.		

Dr. Schultze commences his description of the structure and vital phenomena of the Rhizopoda by referring to the well-known protozoon *Amœba*, Ehr. (*Proteus*, O. Müller); which may be thus briefly described:—Its body consists of a transparent, colourless, contractile substance, whose individual life is manifested by various changes of form, bearing the character of voluntary movement. This contractile substance has the property of throwing out from any part of it a rounded or pointed, longer or shorter process, in consequence of which this simplest of animal forms presents the utmost diversity of shape. No distinction can be perceived of membrane and contents, and no *cilia* are ever observable. The utmost powers of the microscope disclose merely a homogeneous, occasionally fine-granular, transparent (protein-) substance, with irregularly scattered molecular granules, with sharp contours and of strongly refractive properties, imbedded in it, together with some larger, clear, pale vesicles. The former are either fat-drops, soluble in ether, or corpuscles, soluble in a solution of caustic potass, but not so in ether or acetic acid; and the latter often resemble simple vacuities in the substance, having no walls and filled with a homogeneous fluid. The homogeneous *matrix*, as well as the imbedded granules and "vacuoles"—as the cavities above described have been termed—are in a continual kind of flowing motion. The substance appears to be throughout equally capable of movement and equally sensitive; and any part of it appears also to be equally capable of assuming the function of a mouth or vent.*

In the Adriatic Sea, Dr. Schultze met with an *Amœba*, differing from the known species belonging to fresh and salt water by the extraordinary extensibility and active motion of the contractile substance of the body. He terms this species

* *Vide* Description of Actinophrys Sol, by Kölliker, in 'Quarterly Journal of Microscopical Science,' Vol. i., p. 25; and Siebold's Observations on Unicellular Plants and Animals. (Ib., p. 111.)

A. porrecta, and gives a figure of it (Plate VIII. fig. 18). In this form filamentary processes are sent out from all parts of the colourless body. These processes are of some width at their commencement, and soon subdivide into branches. Their length is sometimes eight or ten times that of the body, and they ultimately become so fine that their terminations can only be distinctly seen with a magnifying power of 400 diameters. The form and extension of the body changes every moment, according as the diffluent substance is thrown out into these processes. If two of the processes come in contact with each other they coalesce, forming broadish plates or reticular meshes, which, the change of figure never ceasing, are either retracted into the common mass of the body or are enlarged by additional protrusion of its substance. A continued current of the granules imbedded in the contractile substance accompanies all these phenomena; and in the processes this current follows two directions. On one side the globules may be seen advancing towards the end of the process, where they turn round, and are carried with a comparatively more rapid motion again towards the base of the filament, where they are lost in the substance of the body, unless they may happen to meet another stream, by which they are reconveyed through the same circuit.*

This creature, which resembles in many respects, as will at once be obvious, the well-known *Actinophrys*, may be taken to represent the type of the *Rhizopoda;* and the soft part, or animal as it may be termed, of all the numerous forms included in this class, is constituted in accordance with it. The only essential difference, so far as is at present known, consists in the nature and form of the more or less hard test or shell. Where this test exists, it follows, as a matter of course, that the body itself of the animal cannot change its form, but the shell is always furnished with an opening, or with openings, through which motile processes, exactly like those above described, are protruded and moved. Thus, in the *Arcellæ* and *Difflugiæ*, abounding in fresh water, finger-shaped pro-

* The same *apparent* circulation of granules is observable in the reticular filaments in the body of *Noctiluca miliaris*, first pointed out by M. de Quatrefages; but the reality of which, in the uninjured condition of the animal, Mr. Huxley ('Quarterly Journal of Microscopical Science,' Vol. iii., p. 51) seems inclined to dispute. Our own observations, however (though not very numerous), would lead us to imagine that M. de Quatrefages' account is correct. If so, the remarkable similarity of the movement in those filaments in *Noctiluca* with that observed in the Rhizopods should not be lost sight of, nor the apparent correspondence of the motions of the particles in or on them, with that which may be witnessed in the nuclear currents, or mucous strings, in the *cyclosis* in certain vegetable cells; as, for instance, in the hairs of *Tradescantia*.

cesses are protruded through a large opening in the membranous, chitinous test. In *Arcella* this test is soft and flexible, and in *Difflugia* it is impregnated with silex (in the form of arenaceous particles, *Diatomaceæ*); whilst in other forms, apparently living only in the sea, the body is enclosed in a calcareous shell, though the filamentary processes exhibit exactly the same phenomena as those described in *Amœba porrecta*. These filaments are protruded either from a single large or from numerous minute openings, and are characterised by the active stream of minute globules. Their length is occasionally twelve times the diameter of the body; they branch repeatedly in their course, and are united by delicate bridges and plates. The network of sarcode-substance thus produced not unfrequently covers an area of several lines in diameter, in the midst of which is seated the body of the animal enclosed in its saccular flexible test, or in a delicate chambered shell, like a spider in the centre of its web. These forms constitute the *testaceous Rhizopoda*, and are the subject of the present work. On account of their nautilus-like and chambered shell, they were formerly arranged with the *Cephalopoda*, but were placed in a distinct class by D'Orbigny, under the name of *Foraminifera*. From Breyn (1732) and Soldani (1789-98) they received the name of *Polythalamia*, under which designation they were described by Ehrenberg as a sub-order of the Bryozoa. But neither of these appellations, strictly interpreted, is applicable to the entire protozoan class of Rhizopoda; inasmuch as they are unsuitable to the naked forms, which, as we have seen, must be included in that class. Either, however, might be used to designate that subdivision of the class in which the soft animal is included, in a foraminated or chambered shell.

Owing to the opacity of the shell in many of the Foraminifera, and the strong refractive power of the earthy constituent, it is but rarely that satisfactory observations have been possible in uninjured individuals. It is requisite, therefore, either by breaking the shell, or, what is better, by the careful removal of separate portions of it, to expose the body of the animal. And the same end may also be attained by the careful application of diluted acid. By these three methods it is not difficult to obtain a satisfactory view. It need scarcely be remarked, that the parts external to the shell can be observed without any extraneous aids of the above kind, and that the observation should be made in the living creature.

The *shell* with which the soft substance is closely invested is either *flexible*, or *rigid*, being rendered so by the deposition

of calcareous salts. The only two marine genera in which the shell is flexible are *Gromia* and *Lagynis*, in which it would seem to resemble that of *Arcella*, *Euglypha*, and *Trinema*. In chemical constitution it approaches *chitin*. The flexible shell of these genera and of their fresh-water allies have but one opening, and are not furnished with the minute pores which are found so generally in the calcareous-shelled Rhizopods. All the other Foraminifera are characterised by having a rigid calcareous shell; though there seems to be, at any rate, one exception to this, in a new species described by Dr. Schultze, under the name of *Polymorphina silicea*, in which the shell is constituted of minute granules and angular tables of *silex*, and which might, therefore, be compared with that of *Difflugia*.

When recent Foraminifera are dissolved in dilute acid, an organic basis is always left after the removal of the calcareous matter, accurately retaining the form of the shell, with all its openings and pores. The earthy constituent is mainly carbonate of lime; but Dr. Schultze has satisfied himself of the presence of a minute amount of phosphate of lime in the shells of recent *Orbiculina adunca* from the Antilles, and of *Polystomella strigilata* from the Adriatic.

As respects the *intimate structure* of the shell, the calcareous Foraminifera may be arranged in two series; in one of which the shell is perforated by numerous minute openings or canals, and in the other appears to be solid and homogeneous. In the latter the animal communicates with the external world, either through a *single* large opening, or, instead of that, there may be *several* smaller openings grouped together.

Dr. Schultze has never been able to detect any trace of an organic envelope on the surface of the shell, as described by Carter in *Operculina arabica*.

The chambers of the shell communicate by similar pores and canals through the dissepiments; but of the "interseptal spaces" described by Carter in *Operculina arabica*, and by Williamson in a species of *Faujasina* (neither of which forms had come under his observation), Dr. Schultze has never seen any appearance in other Polythalamia belonging to numerous genera.

With respect to the classification of the Polythalamia, Dr. Schultze takes the mode of disposition of the chambers as the basis of his arrangement. Three principal types are in this way afforded, according as the chambers are disposed in a straight (or slightly curved) line; or in a *spiral* direction; or in confused heaps. The first corresponding with the Stichostegiens of D'Orbigny; the second with his Stelicostegiens, Entomostegiens, Erallostegiens, and Agathistegiens; and the

third including a small number of species hitherto overlooked, and united by Dr. Schultze in the genus *Acervulina*. In Dr. Schultze's arrangement these three divisions constitute as many groups, under the names of RHABDOIDEA, HELICOIDEA, and SOROIDEA.

The Monothalamia he subdivides into three families. The first embracing all the forms having a sacciform, solid, calcareous, or membranous test, with a single large opening. The second is constituted of the single genus *Orbulina*, D'Orb. (*Miliola*, Ehr.), and is distinguished from the preceding by the globose, calcareous test, having no large opening, and perforated all round by *fine* pores. The third family, lastly, includes the genus *Cornuspira* (Schultze), having a monothalamous, calcareous shell, convoluted like that of a *Planorbis*, and furnished with a large opening.

The following tabular arrangement of the Rhizopoda is given by Dr. Schultze, with which we must conclude this notice of his most valuable work.

RHIZOPODA.

A. NUDA.

Gen. Amœba (Noctiluca ?)

B. TESTACEA.

I. MONOTHALAMIA.

Test one-chambered; animal undivided.

1. Fam. LAGYNIDA.—A sacciform, calcareous, or membranous, non-porous test, with a large opening.
   Gen. Arcella, Difflugia, Trinema, Euglypha, Gromia, Lagynis, Ovulina, Fissurina, Squamulina, &c.

2. Fam. ORBULINIDA.—A globose, calcareous test, without a large opening, and finely porous throughout.
   Gen. Orbulina.

3. Fam. CORNUSPIRIDA.—A calcareous test, convoluted like the shell of a Planorbis, with a large opening.
   Gen. Cornuspira.

II. POLYTHALAMIA.

Shell polythalamous; the animal constituted of segments, connected by slender processes.

1. Group HELICOIDEA.

The chambers disposed in a spiral.

4. Fam. MILIOLIDA.—Each chamber occupies a half-spiral; the spires developed either in one plane or in various planes. The shell has only one large opening at the extremity of the last spiral. No pores.
   Gen. Uniloculina, Biloculina, Miliola, Spiroloculina, Articulina, Sphæroidina, Adelosina, Fabularia.

5. Fam. TURBINOIDA.—The spiral formed by the chambers resembles that of the shell of Helix or Turbo. The spiral is only visible on one side of the shell. Some are so much drawn out that the chambers are disposed alternately, as it were, in two contiguous rows. The shell has a large opening in the last chamber, and the surface is almost always finely perforate.

1. Subfam. *Rotalida.*—Shell depressed or conical; chambers not embracing each other; shell glassy, transparent; finely perforate.

Gen. Rotalia, Rosalina, Truncatulina, Anomalina, Planorbulina, &c.

2. Subfam. *Uvellida.*—Shell in the form of a longer or shorter raceme. The chambers frequently almost completely embracing. Shell usually thick and coarsely perforate, or solid.

Gen. Globigerina, Bulimina, Uvigerina, Guttulina, Candeina, Globulina, Chrysalidina, Pyrulina, Clavulina, Polymorphina, &c.

3. Subfam. *Textilarida.*—Spire so much produced that the chambers lie alternately in two contiguous rows.

Gen. Gaudryna, Textilaria, Virgulina, Vulvulina, Sagrina, Bigenerina, &c.

4. Subfam. *Cassidulinida.*—Textilaridans, curved once in a direction perpendicular to the original spiral.

Gen. Ehrenbergina, Cassidulina.

6. Fam. NAUTILOIDA.—The spiral formed by the chambers has a general resemblance to the shell of an Ammonite or Nautilus. The spire is visible on each side of the shell, or not visible on either side. The anterior wall of the last chamber is furnished with one larger or several smaller openings; the remainder of the shell is usually finely perforate.

1. Subfam. *Cristellarida.*—Shell thick, finely perforate, colourless, transparent; chambers embracing, with a large opening at the upper angle of the anterior wall of the last chamber, to which the communicating openings between the separate chambers correspond in position.

Gen. Cristellaria, Rotalina, Marginulina, Flabellina.

2. Subfam. *Nonionida.*—Shell thick or thin, colourless, transparent, finely perforate; chambers either embracing or not. The opening in the anterior wall of the first chamber at the side looking towards the penultimate spiral; the communicating openings of the separate chambers in the corresponding position.

Gen. Nonionina, Haverina, Orbignyna, Fusulina, Nummulina, Assilina, Siderolina, Amphistegina, &c.

3. Subfam. *Peneroplida.*—Usually thin, always brown, transparent shells, with or without fine pores; the

chambers very narrow, embracing or not. Numerous openings, scattered over the whole of the anterior wall of the last chamber; or, instead of these, a large opening produced by the coalescence of numerous smaller ones.

Gen. Peneroplis, Dendritina, Vertebralina, Coscinospira, Spirolina, Lituola, Orbiculina.

4. Subfam. *Polystomellida.*—Shell tolerably thick, colourless, transparent, finely porous; chambers embracing; the anterior wall of the last chamber, besides the fine pores, has either no larger opening at all, or a few very minute, irregular fissures, on the side towards the penultimate whorl. On the surface of all the chambers, rows of fissure-like, often perforating depressions, running at right angles to the direction of the dissepiment.

Gen. Polystomella.

7. Fam. ALVEOLINIDA.—Globose, ovoid, or cucumber-shaped shells, composed of spiral tubes, each resembling a *Cornuspira*, and furnished with a special opening at the end of the whorl. The tubes all communicate by connecting openings, and besides this, are all subdivided by incomplete dissepiments, in the same manner as in the Nonionina. The situation of these dissepiments, which are but few in number, and of the connecting openings, is indicated by meridional lines, which are seen on the surface of the shell.

Gen. Alveolina.

8. Fam. SORITIDA.—Discoid, multicellular shells, exhibiting only in the centre an indication of a helicoid spiral, otherwise cycloid; that is, growing uniformly at the whole border of the disc. The brown, transparent, finely porous shell, is formed of minute chambers, connected together in the direction of straight or curved *radii*, and at the border of the disc, each presenting a large opening.

Gen. Sorites, Amphisorus, Orbitulites (Orbitoides, Orbitulina, Phaculina, Marginopora), Cyclolina (chambers perfectly annular, with numerous openings on the border of the disc).

2. Group RHABDOIDEA.

The chambers arching one over the other, in a straight or slightly curved line, in a single series.

9. Fam. NODOSARIDA.—Rod-shaped shells, whose chambers are superimposed one upon another in a series, and communicate with each other by a large opening; a similar opening in the last chamber. (Except in the genus *Conulina*, where there

are numerous openings instead.) The shell usually thick, perhaps always perforated by fine pore-canals.

Gen. Glandulina, Nodosaria, Orthocerina, Dentalina, Frondicularia, Lingulina, Rimulina, Vaginulina, Webbina, Conulina.

3. Group Soroidea.

Chambers grouped in irregular masses.

10. Fam. Acervulinida.—Chambers usually globose, disposed very irregularly one upon another, and of pretty uniform dimensions; shell finely perforate, and with a few larger openings at indeterminate places.

Gen. Acervulina.

Mikroskopische Untersuchungen ueber die Porosität der Körper. Nebst &c. F. Keber. (Microscopical Researches on the Porosity of Bodies. Together with a Memoir on the entrance of the Spermatic Cells into the *Ovum*. By F. Keber.)

We shall, on the present occasion, confine our remarks to the former of the subjects treated on by Dr. Keber, an abstract of whose Memoir on the Porosity of Bodies, furnished by the Author and translated by Dr. Barry, appears in the 'Philosophical Magazine' for October and November, 1854. Dr. Barry has also appended to it what he terms 'Confirmations' of Dr. Keber's views.

Dr. Keber states, that after many fruitless attempts, he has been so fortunate as to discover in the substance of all organic bodies already formed (though what that means is not very obvious), microscopic spaces from 1-12000th to 1-48000th of an inch in diameter; and generally, in all bodies which he has examined, to recognize signs of an optically demonstrable and measurable microscopic porosity.

It must be understood, however, before going further, that this porosity is not to be confounded with the spaces between the fibres or other constituent elements of organic tissues. The porosity of Dr. Keber is of a much finer kind than this, and is to be sought for in the substance of which the fibres, &c., themselves are composed. To observe such a condition as this, it is obviously requisite that the substance to be examined should be divided into infinitely small portions. Several methods of proceeding are indicated by which particles sufficiently small may be obtained for examination.

1. A very successful method, according to Dr. Keber, consists in the examination of the dusty particles which settle upon glass when left uncovered; though this mode would

seem to be open to the objection that the observer cannot possibly tell what he is looking at.

2. The surface of the body to be examined may be scraped very gently with a knife.

3. As some bodies are too hard for this purpose, the minute particles required are procured by the attrition of two portions of the same substance against each other.

4. The particles may be procured simply by gentle but continued *tappings* upon the glass with the body to be examined. 'This method, it is true,' the author observes, 'takes more time than the others, but is very sure and easy of application.'

5. With bodies that are fresh, and still moist, the mode of proceeding consists in passing the knife most gently over their surface, and laying the *detritus* upon glass, which must be examined without the addition of water, and without a covering of glass. And it is to be observed that the particles of dry substances are also to be examined in the dry state, but that they should be covered with thin glass.

Among the organic and inorganic bodies examined in this way by Dr. Keber, he mentions:—

The shell and membranes of the egg; the *epidermis* and *cutis* of man and many animals; horny substances; hair; the cell-membrane; the mucous and vascular membranes; the walls of capillaries, lymphatics, blood-corpuscles; serous membranes, ligaments, bones and teeth. All parts of plants, and most definitely in the roots! Charcoal, pitcoal, and brown coal; gold, tin, silver, lead, iron, granite, many crystals, &c. The pores of granite (which constituent?) measure in diameter 1-14400th inch; those of iron, 1-24000th to 1-36000th inch; those of steel, which however are very difficult of demonstration, appear to be still smaller. The average size of the pores in all vegetable formations may be taken at 1-18000th inch, among which there occur individual variations of from 1-12000th to 1-24000th inch. The pores in animal formations are about the same size as those of plants. In the membranes of the *ovum* of man and the rabbit they measure 1-14400th to 1-19200th inch, and the same in the human cuticle and skin.

The evidence upon which Dr. Keber relies in support of his assertion of the existence of pores of the above kind in all bodies, is this: that in the *most minute* particles of any kind he perceived, on close examination, what he supposes to be exceedingly minute spaces and clefts, varying in diameter from 1-14000th to 1-18000th inch, the colour of which, but principally with bright illumination, mostly exhibited a

reddish or greenish tinge. Upon long examination he also noticed that the borders of the dust-particles, as well as their finer indentations and inlets, frequently presented *exactly the same* reddish and greenish edges. This accordance in the colouring of the borders, with that of the apparent spaces in the substance of the dust-particles, could not, in the Author's opinion, do otherwise than serve as a confirmation of his belief that he had before him real spaces and minute orifices. Moreover, with the alternate elevation and lowering of the object, and with alternately increased and diminished illumination, he distinctly saw the light flash through them. To the above, which really includes the whole of Dr. Keber's discoveries, we would merely add that his observations were usually made with a magnifying power of 200 diameters and with an aplanatic eyepiece, and with full transmitted light. With this power he was able to perceive in all bodies whatsoever examined by him—including metals, minerals, &c.—the following particulars: 1. As it would seem, that they are composed of scales, all of which are constituted of a delicate net-and-lattice-work of variously interlaced fibres, with *lamellæ* more or less covering one another, which however, partly between them, partly in their substance itself, present a multitude of minute, irregularly-shaped roundish, elongated, indented and angular orifices, spaces or rifts which are sometimes dendritically branched, and form a system of communicating hollow interstices or passages. All to be seen and measured with a linear magnifying power of 200 diameters, and with an object-glass, by Dr. Keber's confession, very far from corrected for chromatic aberration; as we have reason to believe is the case with many object-glasses used by German observers!

The absurdity of these assertions, and of the pretended discoveries of Dr. Keber, will be so glaringly manifest to any one who has had the slightest experience with the microscope, that we should not have occupied a page of the Journal with them had it not been for their appearance in a periodical of such high scientific repute as the 'Philosophical Magazine,' and under the auspices of one who, with all his obstinacy in the retention of exploded views, deserves the greatest respect from every physiologist and microscopical observer. We are sorry to say, however, that Dr. Barry's reputation as an observer will not be enhanced by his fostering of Dr. Keber's extravagant notions; nor do we perceive either that that imaginative microscopist has much to thank Dr. Barry for, in what the latter terms his 'Confirmations' of the discoveries. For, according to the 'Confirmations,' the German observer's pores are not pores at all, but the *nucleoli* of a flat

or discoid *nucleus*, that has divided into many still adherent parts, each part being itself a *nucleus*, and having its single *nucleolus*. It would seem, therefore, that bodies are not porous at all, but solid; and moreover, that gold, tin, silver, lead, iron, granite, and many crystals, are composed of scales, each of which is a flat or discoid *nucleus*, divided into many still adherent parts, &c.!

Dr. Keber's views on the porosity of bodies, and his mode of demonstrating it, require no comment. Any one, with a moderately good object-glass, can of course at once satisfy himself of their fallacy; and we would merely request him, should he ever see our pages, to notice that the old Florentine experiment by no means proves the porosity of gold any more than does the translucency of gold leaf, and that though the irregular fragments of bodies which he has examined with a defective instrument may exhibit the colours and appearances he describes, and though some of them may present actual openings of the size he mentions, it is absurd to deduce from that that all bodies are pervaded by pores, in general not less than 1-24000th of an inch in diameter. The mere inspection of such an object as a scale of *Pleurosigma angulatum*, for instance, in which dots of infinitely less size than that can be seen and measured, and yet in which no pores of any kind are perceptible, is sufficient to demonstrate that *all* bodies are not necessarily porous. Dr. Keber should also remember that although some stones may imbibe water when immersed in it, all do not do so any more than do metals; though according to him all are equally furnished with pores and passages of pretty nearly uniform size.

A MANUAL OF PATHOLOGICAL ANATOMY. By C. HANDFIELD JONES, M.D., and EDWARD H. SIEVEKING, M.D. London. Churchill.

THIS will be a very acceptable volume to the medical profession, because we have no work embracing, in a compressed form, the results of recent researches in the science of pathology. Within a few years, also, the character of much of our pathological anatomy has been rendered much more accurate and comprehensive by the use of the microscope. The authors had thus presented them a very wide field; and if we find defects in this volume, we must rather put it down to the magnitude of the subject, and the necessity of bringing out the work speedily, than to any want of industry and capability on the part of the authors. We have to thank them that they have done so much. Although the whole work is a joint pro-

duction, the authors have taken separately their various especial parts of the work. Thus Dr. Jones has written the department of General Pathological Anatomy with that of the Alimentary Canal and other viscera; whilst Dr. Sieveking has given the Pathology of the Nervous, Circulating, Respiratory and Osseous systems. We think the work would be improved by extending the general department so as to make it embrace all pathological conditions, without the necessity of repeating under the head of each system much of what has been previously stated. This would reduce the bulk of the special department, and give the authors the opportunity of going into greater detail in their account of microscopical pathological conditions. The chapter on parasites, for instance, might thus be greatly extended, especially the portion devoted to their vegetable forms, and the results of such researches as those in Robin's volume on 'Vegetaux Parasites' given.

The volume forms one of Mr. Churchill's medical manuals, and is illustrated with a large series of well-executed woodcuts.

A Popular History of British Mosses. By Robert M. Stack. Reeve. London.

There are few departments of vegetable anatomy that offer a less trodden field for the microscope than the family of Mosses. As yet we are very imperfectly acquainted with the history of their development and the mode of their reproduction. They afford an interest, not only on account of their present distribution on the earth's surface, but also on account of their previous history in connection with the extinct vegetation presented to us in the coal and other strata. This little book does not profess to give an account of the microscopic structure of British mosses; but all those who are studying this subject will find it of great assistance in furnishing the names of particular mosses, and enabling them to identify their specimens. This work is one of the best of the series to which it belongs, and is a very useful addition to the literature of our native botany.

Etudes Physiologiques sur les Animalcules des Infusiores Vegetates. Par Paul Laurent. Tome I. Nancy. 1854.

M. Laurent is known for his microscopical researches; but, unfortunately, the author has adopted theories which evidently interfere with his power of making accurate researches. In the first place, he maintains that there is no distinction be-

tween the animal and vegetable kingdoms, and then proceeds to demonstrate the fact by showing that infusory animalcules are produced from the tissues of plants. His observations are undoubtedly curious, but from his having a preconceived notion to establish, they must all be taken with considerable caution. One of the great objects of the work is to show that the ordinary cells of the cellular tissue of plants become converted into true infusory animalcules. Not only does M. Laurent attempt to demonstrate this fact, but having thus procured his animalcules, he proceeds to give a detailed history of their habits and functions, very different, indeed, from any that has hitherto appeared. The work is illustrated with twenty-two quarto plates, giving coarse though graphic views of all sorts of animalcules; but in these the experienced microscopist will meet with many forms that are familiar enough in ordinary vegetable infusions, whilst in others he will not fail to observe the workings of an imagination bent on supporting a particular view of the facts presented.

NOTES AND CORRESPONDENCE.

On a mode of washing and concentrating Diatomaceous Earths and Clays.—The following method which I have adopted, with tolerable success, consists in making the deposits fall through a constant depth of water, in various periods of time; thus dividing the diatomes, according to their sizes, into portions of several different gravities.

Rule.—Take about a cubic inch of the clay to be examined, digest it for about four hours in strong nitric acid at a moderate temperature; now add gradually an equal quantity of hydrochloric acid, effervescence takes place, a further action on the clay ensues; keep boiling for about three hours more, occasionally stirring, and then allow the mixture to cool and settle down, which it will do in about an hour; pour off the superfluous acid and wash the residue repeatedly with water, so as to get rid of the remaining acid.

The next operation is to divide the sediment into portions of various specific gravities; for this purpose it is necessary to have several beakers, about 3 or 4 inches in height, and about 1½ to 2 inches in diameter; also one very large beaker, about 6 to 9 inches in diameter: we will call the large beaker A. Now transfer the sediment into one of the small beakers, and pour in water till there is just 2 inches depth of water in the glass. Stir and let stand half-a-minute by the watch, and then pour off carefully into the large beaker A; repeat this about half-a-dozen times, each time pouring off into A all that does not fall through the 2 inches of water in the half-minute, and at last the small beaker will contain only what falls through 2 inches of water in half-a-minute. Now let A stand about half-an-hour, pour off carefully, and transfer the sediment in A to another small beaker; put 2 inches of water with it, stir and let stand for 2½ minutes, then pour off into A. Repeat this about six times, and there will now be another small beaker containing all that falls through 2 inches of water in 2½ minutes; while in A is all that does *not* fall through that distance in that period. Let A stand half-an-hour, pour off and transfer the sediment to another small beaker, stir and let it stand *five* minutes, pour off into A as before, and repeat this as before about six times. There is now another beaker, containing all that falls through 2 inches of water in 5 minutes. After this I do not divide them any further, but

call the last remainder, or what remains in A after it has stood its half-hour, "Not in five minutes." Thus we have four different glasses, containing diatomes and clay mixed, of four different densities: thus 0 to $\frac{1}{2}$; $\frac{1}{2}$ to $2\frac{1}{2}$; $2\frac{1}{2}$ to 5; not in 5. There is now a method of concentrating the coarsest of these sediments, namely, the 0 to $\frac{1}{2}$, the $\frac{1}{2}$ to $2\frac{1}{2}$, and sometimes the $2\frac{1}{2}$ to 5. It consists in taking the beaker containing the sediment and pouring about an inch of water on it. Let it settle about 5 minutes and then place the glass on a table, and impart a whirling motion to the whole by moving it round and round, when the greatest portion of the diatomes will rise up in a sort of eddy, while the particles of mud or sand will remain at the bottom, even though they are of the same specific gravity as the diatomes, and have fallen through the same distance of water in the same time. This is because the diatomes are mostly *flat* and *thin*, while the particles of sand and mud are round; in the same way, if we take a round pebble and an oyster shell both of the same weight and throw both horizontally into the water, the pebble will reach the bottom sooner than the oyster shell. So when the whirling motion is imparted to the glass, the thin flat shells of the diatomes will rise up in a cloud, while the round particles of mud and sand will remain behind; when the cloud rises up, pour it off quickly and dexterously into another glass, and, if necessary, repeat the process, and a little practice will enable the operator to separate all the diatomes most effectually. I have said before that this process will only apply to the 0 to $\frac{1}{2}$, $\frac{1}{2}$ to $2\frac{1}{2}$, and sometimes the $2\frac{1}{2}$ to 5 sediment, but not at any finer one; practice may soon teach this. The "not in 5" cannot be concentrated, it is too fine, and the whole rises together on imparting the whirling motion to it.

It is not necessary to abide invariably by the divisions of time which I have given here.

These must be varied, of course, according to the nature of the clay to be examined. For instance, in a clay I have recently tried from 34 feet below the bed of the river at Cardiff, nearly the whole of what was left after the 0 to $\frac{1}{2}$ fell in the $\frac{1}{2}$ to $2\frac{1}{2}$. I, therefore, divided it thus: 0 to $\frac{1}{2}$, $\frac{1}{2}$ to $1\frac{1}{2}$, and $1\frac{1}{2}$ to $2\frac{1}{2}$; a little practice will soon teach this.

The advantages of the plan are, I think, obvious. In the first or coarsest sediments we get all the larger and finer Diatomes by themselves, unmixed with and consequently unobscured by the innumerable smaller ones, and the fine particles of mud and sand; while if any of them, such as the *Eupodisci* or *Campylodisci* are rare, they are *sure* to be found in either the first or second division of densities, and by their

being concentrated and brought as it were into a small compass the detection of them is easy and certain.

In the next division, or the $2\frac{1}{2}$ to 5, we shall find the moderate-sized diatomes; and lastly, in the "not in 5," we get a mass of the remaining and smaller diatomes, all of which small ones are themselves the more readily seen and identified when separated from their larger brethren.

I would venture to add, moreover, that I think the examination of these deposits for the various species is much facilitated, as the slides containing the 0 to $1\frac{1}{2}$ sediment may be examined with the inch objective; the $\frac{1}{2}$ inch will do to examine the $1\frac{1}{2}$ to $2\frac{1}{2}$, and $2\frac{1}{2}$ to 5; while the $\frac{1}{4}$ inch need not be used till we come to the "not in 5," whereas were they all mixed the $\frac{1}{4}$ inch would be required to examine the whole.

I should add, that what is poured off the large beaker A, after it has stood the half-hour each time, may be flung away and the sediment only transferred to the small beakers, as from the large size of it there will rarely be more than 2 inches depth of water in it, and half-an-hour is ample time to ensure every diatomaceous particle atom falling to the bottom and being preserved and detected in one or the other of the divisions.—F. Okeden, C.E.

Aperture of Object-glasses.—As my friend Mr. Sollitt considers the principle that I have proposed, for measuring the angle of aperture of object-glasses, is both complex and erroneous, I may briefly remark, that he himself supports me, with the most substantial evidence possible, of his own perfect conviction of its utility. Simply, because the very method that he has proposed as a substitute, both in its action and use, is absolutely identical with my own; which is, "to use the object-glass of the microscope as the objective of a diminishing telescope." This I accomplished by placing a biconvex lens over the eye-piece.

The next point in question is, with respect to the angle of aperture being reduced upon an object, immersed in balsam; wherein Mr. Sollitt is of opinion, that both the results of Professor Robinson and myself are erroneous.

The methods of measuring apertures under the latter conditions must, of necessity, be altogether different, and form a distinct branch: at present I know of no principle that will serve the purpose so well as that proposed by Professor Robinson. The experiments that Mr. Sollitt has brought forward to prove that it is an error to suppose, that the angle of aperture is reduced in balsam, amounts to no proof at all,

merely because they form no representative of the conditions of an object, mounted *in the substance* of a refracting medium.

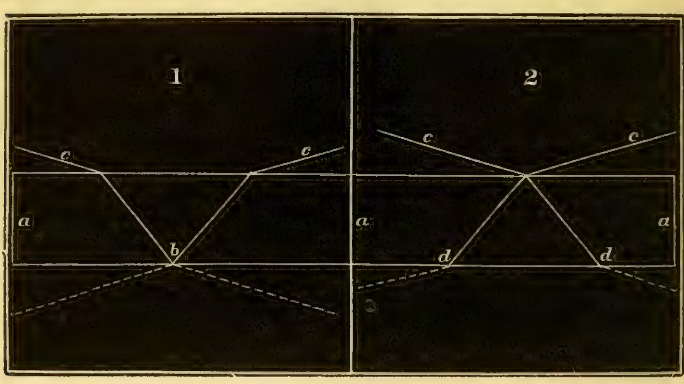
Mr. Sollitt imagines that the theory, as I have explained it, is tantamount to this,—that when a parallel plate of a refracting body is interposed between the object-glass to be measured and the candle, it should reduce the aperture. How he could interpret my meaning thus I am at a loss to conjecture, when I stated distinctly, in my paper in the 'Microscopical Journal,' page 213 :—"That a parallel plate of glass, over an object *mounted dry*, has no effect in reducing the aperture, for the rays, after being deflected by the first surface, emerge again from the second one, parallel to their original direction, and all converge to a point, at the same angle as at first; consequently, the object is seen through the glass, with an angle of aperture the same as if it was not interposed." This is also the case, if several parallel plates of substances of different refractive powers be interposed.

That the candles which Mr. Sollitt made use of exactly represented objects *mounted dry*, there can be no question; and his results are as they should be. But if each candle had been a body contained *in the substance* of a solid block of glass, extending from the object-glass; then a very different indication, or a diminished aperture, would have been obtained.

I imagined that my explanation would have been very easily understood, considering that it strictly depended upon the first law of refraction, contained in any elementary work upon optics. The annexed cut may serve as a particular illustration of the method of measuring the loss of aperture on objects in transparent media. In diagram 1, let *a a* represent a parallel plate of glass, or other medium. Suppose an object to be immersed just within its substance at *b*, to be viewed with an object-glass, whose aperture is *c c*. Now, according to the laws of refraction, the aperture, or angle of rays, collected from the object must be represented by the lines taken from *b* to the points of incidence of the exterior rays of the object-glass, at the upper surface of *a a*. This is the theoretical explanation of the loss of aperture on an object thus mounted.

The practical method of obtaining the actual measurement of the refracted and reduced angle of aperture is demonstrated by diagram 2. Let *c c* again represent the aperture of the object-glass, which is focussed exactly on to the upper surface of *a a*; the rays, *c c*, will be refracted to *d d*, forming an angle exactly similar to that at diagram 1, but inverted. It is therefore evident, that if we measure the base or diameter

of the cone of light, at the under surface at *d d*, the apex being taken from the upper side of *a a*, it will truly represent the loss of aperture caused by the first refraction of the one surface of the medium.



The section of the cone of light at *d d* may be rendered visible by breathing on the under surface of *a a*; but for accuracy I have used a thin film of bees'-wax, as this allows the diameter to be marked with a needle-point with great nicety.

In giving this additional explanation I do not, in the remotest degree, intend to insinuate, that Mr. Sollitt is not perfectly familiar with the theoretical facts upon which this method of measuring apertures is based; but I entirely blame the want of perspicuity, which prevented me from making myself understood in the first instance.

There is a remark contained in my paper, which subsequent observation has induced me to recall, or at least to modify, the very general interpretation to which it is liable. The expression that I allude to was this:—"I have invariably found, that when very difficult tests are mounted in balsam I cannot discover the markings." In contradiction to this, I have lately succeeded, in many instances, in bringing out the striæ on some, of what may be termed very difficult tests when in balsam; but I do not see that this is to overturn the fact, that we are actually seeing such objects with a diminished aperture. But, however, the subject requires an investigation that I have not yet had time to devote to it. I have thought this notice due from me, as I asserted that the statement made by Professor Bailey, of his employing no other than balsam mounted tests, required some further explanation. I may here mention, that it is my opinion, that if an aperture of 125° is reduced to 71° on an object in balsam, it will still have a

great advantage over a clear aperture of 71° on the same object mounted dry; because, if it is really as I have stated, that the visibility of the markings depends upon their opacity, we shall, in the former case, not only obtain more light through the object itself, but there will also be no appreciable loss from the reflection of the containing glass surfaces, as there is in a dry mounting.

To those who may still doubt the question of the loss of aperture, on objects immersed in refractive media, I will recommend a trial of the following simple and instructive experiment, bearing reference to the point in question.

Spread some moistened *Diatomaceæ* on a glass slip, and when dry cover the deposit with a piece of thin glass; place the slide under the microscope, and with an eighth object-glass, select a specimen that may be considered as a test, adjust and focus carefully, and so let it remain. Next, take a drop of oil, or thin Canada balsam, at the end of a wire, and drop it on to the edge of the thin glass cover. If the slide is warm this will rapidly insinuate itself between the glasses. Look through the microscope, and wait for its passage across the field of view; directly that it has passed, it will be found that everything that was visible on the slide, the moment before, has vanished from sight; because the oil, or balsam, has caused a different refraction of the rays from the object-glass, the focus of which has, in fact, become lengthened; for, in order to bring the object again into view, the objective must be brought back a farther distance from the test; it will then be found, if this was at all difficult, that the striæ are *now* totally invisible, under the same conditions of light, and it will require a different arrangement of illumination to bring them out again, together with an alteration in the adjustment of the object-glass. It may be supposed that these effects are analogous to those which would be produced by the interposition of an extra thickness of glass; but just the same phenomena are observed if the objects are adherent to the thin cover itself.

With this example I conclude my remarks. I consider that the main point, that balsam or fluid mounting does create a diminished aperture, still remains an untouched fact.

The inquiry is one of considerable interest; and, as it may end in an application of much utility, should be prosecuted farther.—F. H. WENHAM.

On the Measurement of the Aperture of Objectives.—In your last number I see that Mr. Sollitt proposes a new method for measuring the apertures of objectives, in discussing which

he controverts some opinions expressed by Mr. Wenham and me. On both these I wish to make a few remarks.

I have stated in the paper to which Mr. Sollitt refers that if rays nearly parallel be sent through the eye-piece of a microscope down its axis, their extreme divergence, after passing through the objective, will equal its angle of aperture, which therefore is correctly ascertained by measuring that divergence. The only methods, as far as I know, which do this are the two which I have proposed,* all others depending on the disappearance of a light seen obliquely. Of these Mr. Lister's (Mr. Wenham's, which is similar, I have not tried) is alone correct in principle, but it fails practically in extreme cases. In Mr. Sollitt's, and all of the same type, the process is by no means so certain; on the contrary, they are liable to two serious objections: firstly, that when a pencil of light is inclined at a considerable angle to the axis of an objective, its ultimate angle of divergence is less than the aperture; and secondly, that this angle is not bisected by the ray which is parallel to the original direction. These are obvious from the theory of oblique pencils, and it follows, as a necessary consequence, that we thus measure, not the true aperture, but *twice an angle which is greater than the half of an angle which is less than the aperture.* Up to 45° there is no difficulty in seeing that these two errors nearly compensate each other; but it would be no easy problem to determine their effect at 80° or 85°. To this I may add, that in Mr. Sollitt's method he obtains not the aperture of the objective which he tries, but the sum of it, and that of the lens which he uses as an eye-piece.

I expressed a belief that objectives of large apertures receive less light from an object in balsam than from one which is dry, and I do not see how it can be avoided without also denying the elementary principles of optics. A valve of a diatome (for example) in air disperses light in every direction, as is proved by illuminating it in a dark room with a narrow pencil of sunlight transmitted perpendicularly through it. It is perfectly seen out of the direct beam till its markings disappear by foreshortening, but continues brilliantly visible till the eye comes almost to the very plane of the glass on which it is placed. Now, of this light, so dispersed, all (except what is lost by the reflection of the cover) can come through it to the

* In measuring an objective of 176°, made by Spence, for my friend, T. F. Bergin, Esq., the diameter of the cone's section was so great that I was obliged to modify the method, by receiving the light on a screen made to travel in a cylindric surface concentric with the focal point. This is a decided improvement, but requires the use of a graduated circle. The result must, of course, be corrected for penumbra, &c.

objective, even with 180° of divergence. In balsam there must be the same dispersion of light; but beyond a certain obliquity, it cannot emerge. The refractive index of Canada balsam is 1 540, and that of such flint glass as I use for covers 1·550; with these Mr. Sollitt will find that the limit is 40° 30′ from the perpendicular, and that below this all the rays must be reflected back and be absorbed or escape at the edges of the slide. How much is thus lost cannot be assigned without knowing how the intensity of this dispersed light varies at different obliquities; but if it be uniform, then the balsam unquestionably cuts off a portion of it whose quantity is measured by the difference between a hemisphere and a segment whose amplitude is 81°, or 0·76 of the whole. In air the light will pass almost to 90°.

The first argument by which Mr. Sollitt endeavours to overthrow this inference is, that he finds his measures of aperture the same, whether he interposes in the course of the light a plain slide or one with balsam. This must be the case; for every one knows that a ray incident on any system of media, bounded by parallel surfaces, emerges parallel to its original direction.* But though it will pass the media, even up to 90°, its course *in them* is always within the angle of total reflection, and the light whose loss I have described comes not by direct transmission, but by dispersion. How that dispersion is produced I do not now inquire; but its existence is a fact.

His second argument is, that test objects are as well seen in balsam as when dry. This is not in accordance with my experience, and I believe is not generally admitted. It is true that a body of irregular surface and high refractive power is (especially as to its internal structure) best seen in balsam; but this is a special case, and does not apply to one which, like the valve of a *Pleurosigma*, is thin and flat. Indeed, besides the point in question, this medium may be expected to injure vision by weakening the dispersion and reflection of the light. The refractive index is nearly that of quartz for the ordinary ray, which is probably the same as that of silica, as it exists in these valves, having no active or polarized light;† if it were exactly the same, neither the valve nor its markings could be seen at all, and as it is, its action makes the latter

* It is shifted a little sideways, which is the reason that we can use these large apertures with covers of a certain thickness, but this can make no change in the measure.

† In this respect they contrast strongly with undoubted vegetable productions, such as the siliceous integuments of grasses and *Equiseta*, the hairs of *Deutzia*, &c.

finer and fainter. If Mr. Sollitt will repeat one of my experiments, select a single valve, whose details are barely visible when dry (the objective may be of moderate aperture), successively introduce under its cover, water, alcohol, and balsam, and use very deep eye-pieces, which are the sure tests of deficient light, he will probably find reason to change his present opinion as to the effect of dense media.

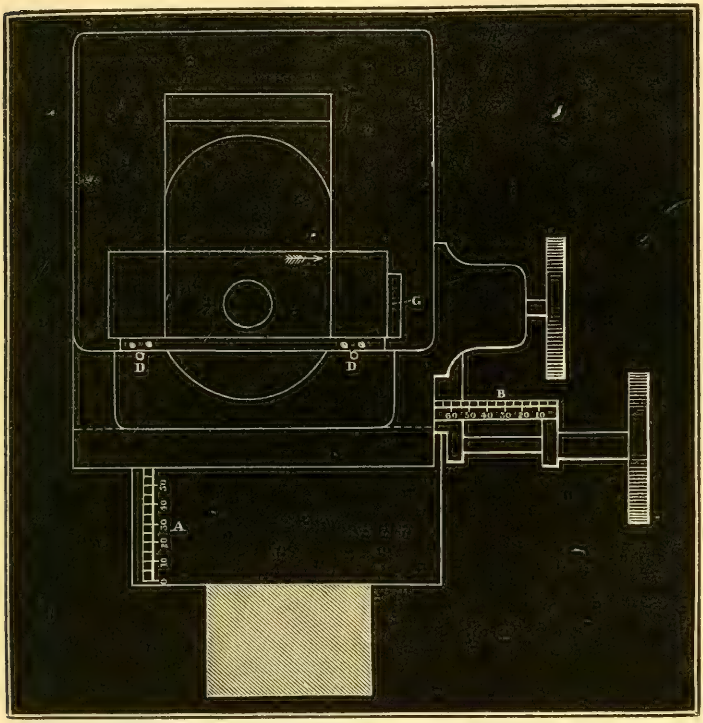
It may be of use to some of your readers to know that I have ascertained the nature of the irregularity which injured the circumference of the objective described in my paper as No. 4. (Quarterly Journal of Microscopical Science, vol. ii. p. 296.) I sent it to a distinguished optician, Mr. Grubb, of Dublin, to have a graduation put to its compensation, who, on taking it asunder, found that a little of the cement which unites the lenses was visible round the edge of one: this he very cautiously removed. I was struck with the improved performance of the objective, but referred it to the superior action of a new microscope which he had made for me, till I happened to use it for the purpose of shewing the nature of this defect to a friend. To my surprise it was gone, and the disc of light was unbroken to the edge, giving 129° instead of 102°, which had been the really effective part of the aperture. I do not pretend to say that the same occurred in the others which I examined (in No. 6 the case was certainly different); but it is, at least, desirable that when such a defect is found, this probability should be kept in mind.* — J. R. ROBINSON, D. D., *Armagh.*

On an improved Finder for the Microscope.—The accompanying plan for a *finder*, I have used for some time, and as I have found it to work very well, and as it has moreover been seen and approved of by two or three veteran microscopists, I have ventured to send a description of it to your Journal.

The drawing I send is a view of Ross's stage to his best microscope, which is the instrument I use, and to which I have adapted the finder.

* This microscope deserves to be known: among other valuable improvements it has anticipated, and in a better form, one proposed in your last number, as "a new achromatic condenser." Mr. Grubb's illuminator is a prism whose aberrations are corrected for a lamp placed at a given distance in the plane of the stage. It travels on a graduated arc of 120°, and through this range its focus continues on the object, sufficiently bright for the highest powers. I have used it at 50° with 3200, and find the power of examining tissues at various obliquities very useful. If raised above the stage it gives at once a capital illumination for opaque objects; it acts well with Lieberkuhn and Nicol's prism, and trifling additions make it equally effective with Mr. Bergin's parallel illuminator, which shows some objects with peculiar distinctness.

This consists of two scales; one of them, the vertical, A, is attached to the main bed-plate of the stage; the other,



or horizontal one, B, is attached to the arm carrying the pinion which works the vertical stage. These scales are made on thin paper, and on examining a Ross's microscope, it will be found that there is ample room for each stage to work over its respective scale. The horizontal scale B is carried on a little way, and fixed on the plate of the vertical stage, as well as to the arm before mentioned.

The only thing else required is a small brass stop, fixed on the sliding plate at G. This is for the slides always to abut against; and also two little pegs, or stops, at D D; these are fixed into the revolving plate, and are for the sliding plate to abut against. These three stops are removable at pleasure.

The mode of using the finder is obvious:—If, for instance, I am about to examine a slide of any deposit, for diatomes, I place it on the stage, close up to the stop G, and bring the sliding plate down on the stops D D, and set the revolving

plate square to the axis of the microscope; on sweeping through the slide, if any particular form occur worthy of note, its position is at once read off on the two scales, and noted thus, "*Triceratium favus* $\frac{40}{20}$;" the upper numbers referring always to the horizontal scale, and the lower numbers to the vertical.

If I wish at any time to find *T. favus*, I have merely to bring the horizontal stage over 40 on its scale, and the vertical stage over 20 on its scale, when *T. favus must* appear. Thus the whole contents of a slide may be speedily catalogued and registered, and as speedily found again when required. A small arrow scratched upon each slide serves to show the direction in which it is laid, for registry or reference. The divisions I use are 1-5ths of an inch; each is again divided into 10 parts: each of these may be divided by the eye into half, so that when the stages do not come exactly over a division, I register them thus: *T. favus* $\frac{40\frac{1}{2}}{20\frac{1}{2}}$. It is obvious, that when working at night these scales will be in the dark; I then use a small silvered reflector, about two inches square, which fits into a handle, and throws ample light upon either of the scales, with a little management.

In the study of diatomaceous deposits this method of registering is especially serviceable, as the whole contents of a cabinet may be registered in a book, and any specimen referred to in a moment, without the least trouble or loss of time.

I am indebted to my esteemed friend, B. Brodie, Esq., for the suggestion of the above contrivance.—F. OKEDEN, C.E.

On the presence of Starch in the blood of an Epileptic Patient.—During the latter part of last year (1853) a gentleman, residing in Toronto, troubled with epilepsy, stated to me that he was desirous of having his blood examined by means of the microscope, hoping thereby that something might be discovered in it which might explain the cause of his complaint. Being fully aware of the great influence which the delayed excretions of the system exercise when retained in the blood, I readily acceded to the request, thinking it possible that I might find some changes in the blood corpuscles, or in the deportment of the fluids, that might assist in the investigation or serve to explain the nature of the affection. Having obtained some blood by puncturing the finger with a lancet, I took a drop and placed it in the field of the microscope—my microscope is a Nachet's, magnifying from 450 to 500 diameters. To the drop of blood I added some pure well-water, the red corpuscles rapidly absorbed the fluid, and soon

broke up; after a short time I found left under the microscope many white corpuscles, and a number of cellæform bodies which I compared to starch corpuscles; these bodies were of irregular size, with a minute nucleus, presented an apparent lamination, were generally ovate, flattened and some what irregular in their outline, and bore all the appearance of these vegetable corpuscles. Fancying that they might be some foreign matters obtained from the water, which had been mixed with the blood, I requested a fresh supply of water in perfectly clean utensils, and used every precaution to obviate any accidental introduction of starch. Still upon placing some more blood under the field of the microscope I observed these bodies. One fact was evident, that if I put some of the blood under the microscope without the addition of water, the blood corpuscles ran together and broke up, without showing any of the bodies I imagined to be starch corpuscles. When developed to their ordinary size, they were about 1-500th of an inch in diameter, which would make them too large to pass the generality of capillary vessels; after some water had been added to the blood these corpuscles, not at first remarkable, after a time became very conspicuous, and were evidently fully developed by the water they had absorbed. The dense medium in which these bodies previously existed was certainly not favourable to their increase of size, but, as soon as a finer fluid had been added, they quickly enlarged and eventually assumed the appearance which attracted my notice.

Greatly surprised, I mentioned the fact to my patient, telling him that I must be deceived by some unaccountable accident, and that the introduction of the starch into the blood must depend upon some fortuitous circumstances, as I had never before heard of such a case, and did not believe that a vegetable product like starch could exist in the blood of man. So convinced was I that the product observable in the field of the microscope was starch, that I obtained some flour and placed it under similar circumstances in the field of the microscope, its apparent identity was sufficiently manifest; still fearing that there must be some mistake, I did not venture to imagine that there could be any reality in my discovery of starch in the blood of man, and consequently passed the matter over without further observation. At a subsequent period I discovered with my friend, Dr. Barrett, similar bodies during our microscopic observations of the matter contained in the eye of a boy, which had been removed in consequence of *fungus hœmatodes*, and I have continually observed similar corpuscles in specimens of urine submitted to the same test.

Having lately observed (15th June, 1854) that Rudolph Virchow had published in Virchow's Archiv. Bd. VI., H. 1, page 135 (Sept. 4, 1853), an account of his discovery of a substance presenting the chemical reaction of cellulose found in the brain and spinal cord of man, I mentioned the fact to my patient, told him that it was possible that the discovery which I had made of starch in his blood might be a reality, and consequently I thought it would be well to make another observation of the matters contained in his blood. Upon placing a drop of the patient's blood under the microscope it exhibited the same corpuscles, and I now resolved to test them with iodine; accordingly I made a watery solution of iodine, and applied it to the drop of blood instead of the water previously employed, and found that every one of the bodies I fancied to be starch-corpuscles became blue—some were of a light purplish-blue tint, while others became opaque, and of a perfectly blue colour. To satisfy myself as to the precise character of these bodies, I now took some flour and mixed it with the weak watery solution of iodine, and precisely similar results were produced, therefore I consider that I am warranted in believing that the bodies I observed under the microscope, in the blood of the patient afflicted with epilepsy, were corpuscles of starch; and that under ordinary circumstances, while floating in blood of the usual consistency, these bodies are scarcely more than granules, and continue as such so long as they remain in the circulating system; but when they have been removed from the blood, or submitted to a less dense fluid, that they then rapidly take up fluid, and are readily developed into full-sized starch-corpuscles, and may be shown as such in the field of the microscope.

While adverting to this singular fact, I will not presume myself to offer any reasons as to the physiological or pathological value of the conclusions that may be drawn from the circumstance, save that it seems to confirm the opinion advanced by Virchow, when he states that "In the brain of the child I have as yet sought for it (the cellulose) in vain, so that like the brain-sand it appears to arise in a later stage of development, and probably may have a certain pathological import." Is not this evidenced by the starch-corpuscles occurring in the blood of a patient subject to epileptic attacks? It is not impossible that the starch corpuscles found in the brain, and other abnormal structures of the body, may have been derived from the blood, and have been deposited in the diseased structures, as one of the products of inflammatory action; at that period they were scarcely more than *nuclei*, but after they had been removed from the circu-

lating system, and obtain a thin serous fluid for their nourishment, they then become so far developed that they may be readily diagnosed in the animal structures as corpuscles of starch.—S. J. Stratford, M.R.C.S., England; Editor of the 'Upper Canada Medical Journal,' Toronto, Canada West.

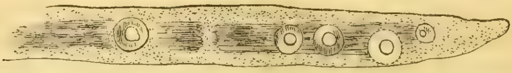
Structure of Closterium.—A paper in the last number of the 'Microscopical Journal,' by the Hon. and Rev. S. G. Osborne, on the Economy of *Closterium Lunula*, induces me to offer a few remarks on the same topic, as, though my observations have been trifling compared with the labour which Mr. Osborne has devoted to those beautifully interesting objects, some drawings and jottings in my note-book entirely coincide with his illustrations, and afford one or two additional details.

In February 1853, I first noticed around the margin of a *C. Lunula* the appearance of a double circulation passing in opposite directions through canals or vessels, one of which was, probably from refraction, of a bright pink colour, the other a pale green. The motion of the currents was nearly uniform, but occasionally intermittent; and sometimes for a few moments the direction of the currents would appear to be reversed. The circulating liquid carried with it minute granules by which its course and velocity were apparent; and on carefully observing these, it was evident that the marginal vessels poured their contents into a diffused cavity, free from endochrome, surrounding the hyaline vesicle with its perplexingly active group of moving bodies. These vary in number from sixteen to twenty or thirty at each extremity of the frond; and a supplementary vesicle is sometimes added, containing a single granule in equally brisk activity. The transparent membrane of this terminal cavity of the frond appears covered with cilia, which I have also distinctly seen fringing the inner margin of the crescent, and less clearly also on its outer edge.

The appearance of a marginal circulation, which passes uninterruptedly across the central band of the *Closterium*, may or may not be due to ciliary motion, or currents thereby induced. But besides this (apparent) circulation in marginal vessels, there is a frequent irregular movement of granules of endochrome more resembling imperfect cyclosis; and a detached granule is occasionally seen to stray into the marginal current, and to be carried by it to the terminal cavity, where it appears to have lost its way and to seek in vain for a resting place.

Another point to which I would ask attention is the occurrence of remarkable circular marks or apertures, which are observed more or less distinctly on many specimens of *Clos-*

terium. They are alluded to by Mr. Osborne, and are depicted in several of Ralf's figures, particularly in *C. Ralfsii*, and were even more definitely displayed in several fronds of *C. didymotocum*, sent to me among some mud from near Beaumaris, of one of which I took an outline with the camera in my note-book, in July 1853, resembling the sketch enclosed.



This frond seemed nearly, or quite dead; it was partly transparent, the endochrome contracted, and some portion had escaped. Several apertures penetrated both layers of the investing membrane at irregular intervals, the inner circle of the aperture being the more distant from the eye in all save one (marked ×), in which the larger orifice seemed in the opposite direction. All around the apertures and over the entire space not occupied by endochrome, were crowded myriads of excessively minute atoms in active motion. Are these perforations accidental or belonging to the economy of the *Closterium;* and have they any affinity with the mysterious hyaline globule at its extremity? I have noticed groups of busy granules in apparently hyaline vesicles on the dark surface of the frond, though I could not identify them with the spots here designated as apertures.

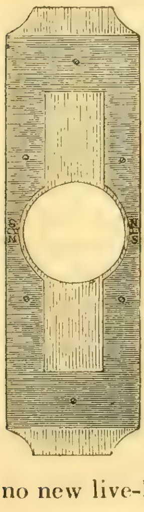
The application of iodine was merely a repetition of Mr. Dalrymple and others' experiments, and, like his early attempts, failed to denote the presence of starch in the endochrome. And yet the *Closterium* seemed a fully mature specimen.

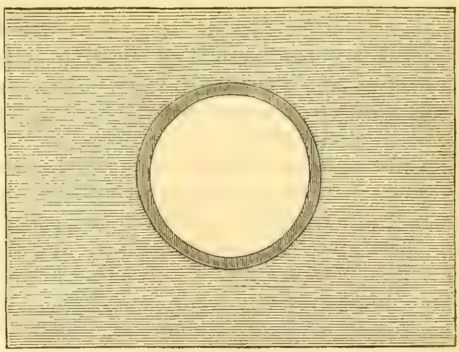
I have not had leisure to watch the process of division observed by Mr. Osborne, but have noticed the motion of the *Closterium* from side to side, recorded by him, a movement which appeared to me perfectly spontaneous; and, indeed, without some means of spontaneous motion it is difficult to conceive how the frond (I had almost said the *animalcule*) becomes removed from the bottom to the sides of a glass, a fact I have especially noticed in some of the kindred species, *Docidium.*

The above observations were made chiefly by the light of a camphine lamp, or of a sperm candle intensified by a Ross' condenser, and with one of Ross' 1-8th of an inch objectives, of 150° angle of aperture. I have not yet used the direct sunlight recommended by recent observers, but shall certainly adopt it when the return of spring gives further opportunities for the re-investigation of these very beautiful and interesting objects.—F. G. WRIGHT, M. D., *Wakefield.*

Prevention of Glare from Artificial Light.—The following very simple plan for correcting the painful glare of artificial light, particularly gas light, in microscopical investigations with low powers may have been adopted by others, but as none of my microscopical friends are aware of it, and as I can find no allusion to it in any works on the microscope with which I am acquainted, a short note on the subject may not be out of place amongst your 'Memoranda.' I have had slips of bluish-grey glass of various shades cut to the size of an ordinary glass slide three inches by one. One of these blue slips I place upon the stage under the glass slide bearing the object, or, if more convenient, place the object to be examined upon the blue glass itself. This little contrivance renders the observer quite independent of a blue chimney-glass to his lamp, and enables him readily to change the tint of the light and adapt it to the particular object he is examining at the moment. By this plan the yellow light of common gas is converted into a pure and white light, approaching very closely to that of daylight. The blue glass may be obtained from any working optician, being the glass used in the manufacture of blue spectacles, and I am confident the observer will derive real comfort from its use in the manner indicated.—Ferguson Branson, M.D., *Sheffield.*

Magnetic Stage.—I send you a drawing and description of a magnetic object-holder, not liable to an objection incidental to the otherwise excellent arrangement described by Mr.



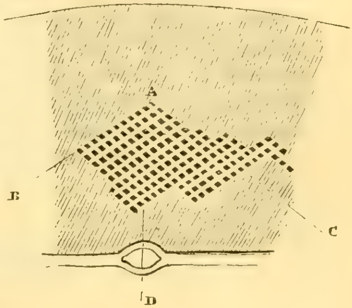


Busk, in the July number of the 'Microscopical Journal, inasmuch as it is applicable to the stage of *any* microscope, whether simple or not, and also requires no new live-boxes or object-holders, being applicable to those

already made. The arrangements requires the upper edge of the aperture in the brass plate of the stage to be turned down (in a lathe) so as to form a cell 1-8th of an inch or more broad, and of sufficient depth to allow of a slight shoulder on the lower edge of the plate. Into the cell thus made a soft iron ring, cut or turned out of sheet iron, is firmly pressed, being so made as to fit tightly. If required, small adjusting screws may be introduced beneath to regulate the requisite projection of the soft iron ring above the surface of the stage. The magnets *are attached to the live-box or object-holder*, and as the surfaces of adhesion are by this plan large, they may be much reduced in weight and more easily made, being punched or cut out of soft sheet cast steel 1-16th inch thick, and afterwards hardened in the usual way. The subjoined drawing shows the mode of attachment to the under surface of the brass live-box or object-holder, and which may be effected either by screws or solder, taking care that the *opposing* and *dissimilar* poles of the magnets are brought as near as possible without contact. As magnets always lose power by frequent breaking contact, this arrangement allows them to be remagnetized without any disturbance of the stage of the microscope. Both magnets and soft iron ring require to be ground flat.—J. B. SPENCER, 9, *Kidbrooke Terrace*, *Blackheath*.

Curious effect of moisture on the markings of the Pleurosigma.— In the Introduction to the 'Micrographic Dictionary,' now publishing by Van Voorst, and of which Dr. Griffith and Mr. Henfrey are the authors, it is stated, page xxxiii, "In the valves of the more delicate Diatomaceæ (*Gyrosigma*, &c.), the point is important that the line of fracture of the broken valves passes through the rows of dots on the dark lines corresponding to them, showing that they are thinner and weaker than the rest of the substance; had these dots represented elevations, the valves would have been stronger at these parts." This appears very conclusive, but a phenomenon has recently come under my notice which, to my mind, is easily explicable on the supposition that the dots are *elevations;* not so, however, on the hypothesis that they are *depressions*. On a slide containing the *Pleurosigma hippocampus*, mounted *dry* by the late Poulton (whose recent loss many microscopists will I am sure deplore), there is one specimen of a *Pleurosigma* which I am unable to identify with any in the Rev. W. Smith's Synopsis. Some moisture has gradually insinuated itself between the thin glasses of the slide, and has almost entirely obscured the markings which I used formerly to see most beautifully as dots all over the surface of the shell. However,

on submitting the slide to a gentle heat, I found that the moisture slowly retreated, leaving patches of the shell dry, and with the markings as distinct as before. But what I particularly desire to draw attention to is, that I have observed the dry part of the shell is uniformly bounded by *straight* lines, which are *parallel* to the two directions of *least* distance of the dots. This will, perhaps, be better understood on referring to the figure, which is an enlarged diagram of a portion of half the shell, and in which the portion in dots is a careful copy of a dry part of the shell, where the markings are clearly seen; whilst the shaded remainder of the figure is intended to represent the parts obscured by the damp, in which only a very slight trace of the markings is visible. In the figure it is evident that there are two lines, AB and AC, in the directions of which the dots are at a minimum distance, and I find that the straight lines of demarcation between the moist and the dry portions are almost universally parallel to these two directions.*



Now upon the supposition of these little dots being elevations, the phenomenon appears to me easily explicable, on the principles of capillary attraction. We can readily conceive the moisture clinging from one dot to another, and it would always have a tendency to arrange itself in lines parallel to the directions of least distance. I am, however, quite at a loss to imagine how the same principle would apply on the hypothesis that the dots are depressions; nor, on that hypothesis, do I see upon what principle the phenomenon is explicable. The examination has been made throughout with one of Ross's recent 1-8ths (1854), and a carefully centered achromatic condenser, with stop to cut off the central rays. I always observe that when I have the most distinct vision of the dots, if I very slowly turn the fine adjustment so as to depress the object-glass, the dots suddenly become white on a black ground, and under these circumstances I have sometimes thought I could see the white dots having an hexagonal form; but even with the third eye-piece, I have not command of

* From geometrical considerations it is evident, that if the angle BAC be greater than 120°, the straight lines parallel to the straight line AD are in the directions of the minimum distance of the dots, but by a careful drawing with the camera lucida I have found that the angle BAC is less than 120°.

sufficient power to be assured on this point. The fact of these delicate markings being almost entirely obscured by moisture appears to me remarkable, and calculated, if investigated by experienced microscopists, to throw much light on a subject still I presume involved in obscurity, namely, the precise nature of these markings. I may observe that I have another slide of the *Pleurosigma angulatum*, in which, from the same cause, the phenomenon is very visible.—G. HUNT, *Birmingham.*

Notes to Mr. Currey's Paper on the Threads of Trichia.—The following misprints occur in this paper. At p. 20, the word "accurate" is printed instead of "arcuate," which renders the sentence unintelligible. In two places Trichi*a* is printed, where the word should be Trichi*æ*, and in one place Arcyri*a* is printed instead of Arcyri*æ*.—FREDERICK CURREY.

PROCEEDINGS OF SOCIETIES.

MICROSCOPICAL SOCIETY. *June* 28*th*, 1854.

Dr. Carpenter, President, in the Chair.

T. H. Huxley, Esq., Joseph Payne, Esq., E. B. Pitchford, Esq., and F. Spurrell, Esq., were elected Members.

Dr. Lankester made some remarks on the circulation in *Closterium Lunula*, and read portions of a communication to the Microscopical Journal, from the Rev. S. G. Osborne, on the subject.

A paper on the Parasitic Borings in Fossil Fish-scales, from C. B. Rose, Esq., was read (Transactions, vol. iii., p. 7).

Mr. Quarles Harris made a communication on the disease affecting the Vine.

October 28*th*, 1854.

The President in the Chair.

Three separate papers from Professor Gregory, of Edinburgh, on Diatomaceæ, were read (Transactions, vol. iii., p. 10).

November 22*nd*, 1854.

The President in the Chair.

H. Rutt, Esq., and Fitzmaurice Okeden, Esq., were elected Members.

A paper was read from Mr. Wenham, entitled, "Some Remarks on obtaining Photographs of Microscopic Objects," &c. (Transactions, vol. iii., p. 1).

ORIGINAL COMMUNICATIONS.

On the Occurrence *among the* Infusoria *of peculiar* Organs *resembling* Thread-cells. By George J. Allman, M.D., F.R.S. (With a Plate.)

(Read at the Meeting of the British Association at Liverpool, Sept. 1854.)

In an important monograph by Cohn on the *Paramœcium Bursaria*,* this author maintains that the cilia with which the whole surface of the animalculæ is covered are in reality much longer than their appearance in the living animal would lead one to believe. He founds this opinion on the fact, that when the animal is allowed to dry on the glass object-holder it is seen to bristle with long rigid filaments, which he believes to be the cilia, really unaltered in length, though then for the first time become visible in their entire course; and, in accordance with this view, he figures the *Paramœcium* covered with cilia very much longer than the inspection of the living animal alone would justify.

Stein, in his remarkable work on the development of the Infusoria,† refers to this opinion of Cohn, whom, however, he considers in error, in supposing the long bristle-like processes of the dead animalcule to represent the *natural* length of the cilia in the living. He maintains on the contrary that these processes are the cilia *abnormally* lengthened under external influences; and he states that he has witnessed the same phenomenon in many other *Infusoria* in which he has always been able to induce it by the application of strong acetic acid, when the cilia suddenly extend themselves to three or four times their original length.

While recently engaged in examining the structure of a nearly allied animalcule, the *Bursaria leucas*, Ehr.—a green variety of which was developed during the present autumn in great profusion in a small pond in the county of Essex—I witnessed an appearance exactly similar to that described by Cohn and Stein; but it soon became clear to me that the German naturalists had erred in their explanations of it; and I am now satisfied that the filaments in question have nothing whatever to do with the cilia, but are peculiar and very remarkable organs, hitherto undescribed in the *Infusoria*.

When this animalcule is examined under a sufficiently

* Siebold u. Kölliker Zeitschrift. Bund III. 260.

† Die Infusionsthiere auf ihre Entwickelungs geschichte. (' Quarterly Journal of Microscopical Science,' Vol. ii., p. 272.

high power, minute fusiform bodies may be detected thickly imbedded in its walls. (Figs. 11 and 12 and 14 *h*, Plate X.) These bodies are perfectly colourless and transparent; they are about the 1-2500th of an inch long, and may easily, even without any manipulation, be witnessed at the margin, where they are seen to be arranged perpendicularly to the outline of the animalcule, while on the surface turned towards the observer their extreme transparency and want of colour render them invisible against the opaque back-ground, and it becomes necessary to crush the animalcule beneath the covering-glass so as to press out the green globules which it contains, in order to bring the fusiform bodies into view. To these bodies I propose to give the name of *trichocysts*.

As long as the animalcule continues free from annoyance, the trichocysts undergo no change, but when subjected to external irritation, as occurs during the drying away of the surrounding water, or the application of acetic acid or other chemical irritant, or the too forcible action of the compressor, they become suddenly transformed into long filaments, which are projected from all parts of the surface of the animalcule (fig. 13); and it is these filaments which, being mistaken for cilia by Cohn and Stein, gave rise to the erroneous views just mentioned.

The rapidity with which this remarkable change is effected, joined with the great minuteness and transparency of the object, renders it extremely difficult to follow it, and for a long time I could only satisfy myself of the fact that the fusiform bodies were suddenly replaced by the projected filaments. After continued observation, however, I at last succeeded in witnessing the principal steps in the evolution of the filament.

It is not difficult, by rapidly crushing the animalcule, to force out some of the trichocysts in an unchanged state. (Fig. 15.) If the eye be now fixed on one of the isolated trichocysts, it will most probably be seen after the lapse of a few seconds to become all at once changed with a peculiar jerk, as if by the sudden release of some previous state of tension, into a little spherical body. (Fig. 16.) In this condition it will probably remain for two or three seconds longer, and then a spiral filament will become rapidly evolved from the sphere, apparently by the rupture of a membrane which had previously confined it, the filament unrolling itself so quickly that the eye can scarcely follow it (fig. 17), until it ultimately lies straight and rigid on the field of the microscope, looking like a very fine and long acicular crystal. (Fig. 18.)

This remarkable body when completely evolved (fig. 18 *l.*) consists of two portions—a rigid spiculum-like portion acutely pointed at one end, and continuous at the opposite end with the second portion, which is in the form of an excessively fine filiform appendage less than half the length of the spiculum: this second portion is generally seen to be bent at an angle on the first, and is frequently more or less curved at the free end. The form of the evolved trichocysts is best observed in such as have floated away towards the margin of the drop of water, and are there left dry by the evaporated fluid. In many of them the filiform appendage was not visible, and they then merely presented the appearance of a simple, long fusiform spiculum. (Fig. 18 *k.*)

The resemblance of the organs now described to the well-known thread-cells of the Polypes, and of certain other lower members of the animal kingdom, is obvious. That they are entirely homologous, however, with these bodies we can scarcely yet assert. Their origin, at least, appears to be different; for if we admit the unicellular structure of the *Infusoria*, we have the trichocysts apparently developed in the substance of the cell-wall, instead of being produced in special cells, as we know to be the case with the thread-cells of the Polypes.

Snow Crystals *in* 1855. By J. Glaisher, Esq., F.R.S.

(Read before the Greenwich Natural History Society.)

The many snow crystals which fell during the late severe weather, attracted such general attention, that I ventured to announce a paper on the subject for the present evening. Never do I recollect such an infinity of crystals as have lately fallen beneath my observation. Generally speaking, they fall at rare intervals and very sparingly, in cold and calm weather, and frequently at the commencement of a thaw. In the present year they have fallen under all circumstances of wind or calm, with snow, and alone, during the continuance of the late severe weather when the temperature varied from a few degrees above zero to the freezing point, and up to the precise moment of the thaw, with a temperature of from 34° to 37°. The size of these beautiful objects was by no means unappreciable, and might be said to vary from 0·05-inch to 4-10ths of an inch in diameter. Their forms were so varied, that it seemed scarcely possible for continuous observations to exhaust them all. I therefore endeavoured to secure observations of those which might be considered types of their class, trusting to a

future opportunity to extend my acquaintance with the separate varieties which each class included. In accordance with the law that water crystallizes at an angle of 60°, the base of every figure was a hexagon of six rays. These rays, in passing through successive stages of crystallization, become encrusted with an endless variety of crystalline formations, some consisting of thin laminæ alone, others of solid but translucent prisms, heaped one upon another, and others gorgeously combining laminæ and prisms in the richest profusion.

At the beginning of the frost, the kind which was most common, and attracted universal attention, was of simple six-rayed stars, with a central molecule of snow. These fell in clusters of several in a group, and in their descent had the appearance of tolerably large and fleecy snow-flakes. The ground had for some days been covered with snow; but where the soil was visible, they lay like ravellings of fine white cotton, knotted here and there, an effect produced by the large white molecule, the centre of each star. I chanced to be in the neighbourhood of Abbey Wood, when a shower of these fleecy-looking groups began to fall. The air was calm, the snow lay upon the ground, and the sky was overcast. The surface of the snow was soon covered with clusters of these figures, beautiful in their simplicity. They were certainly 4-10ths of an inch in diameter, and could be readily distinguished. The temperature at this time was at or near 32°. After falling about a quarter of an hour, they became intermingled with a variety of very complex crystals. Some of these last exhibited all the rigidity but harmonious proportions of geometric figures; others the fanciful luxuriance of the fronds of the Lady fern; others, again, exhibited an arrangement of trefoils, and some there were, with pinnæ of unequal size, three being large and fully-developed, of fern-like character, and three being little more than spiculæ. The air, during the continuance of the shower, was considerably cooled, and was at its coldest when these beautifully-varied figures were falling. Towards the close of the shower, fleecy groups of stars were again prevalent, the air was less cold, and half an hour after, when the shower ceased, the sun was endeavouring to penetrate the gloom which before prevailed.

I will endeavour briefly to describe the departures from the ordinary or primitive form.

On February 8, the day of the first heavy and continued snow, I secured drawings of some of the most remarkable figures which fell in numbers throughout the day, and accompanied the snow. The minimum temperature of the preceding night had been 29°; at 9 o'clock the thermometer in air was

32°, and the maximum during the day was only 32°. During the early part of the morning there fell an immense number of hexagonal plates of ice; some of these were of simple laminæ, but others were marked very beautifully with inner lines, and resembled in form and character many of those seen by Scoresby in the Arctic seas. Towards noon, I perceived several of more complicated figure, of which the hexagon of the morning formed the nucleus. Figs. 1, 2, 3 (Pl. XIII.) are a few of several that I sketched at this time, and were viewed through a lens of somewhat less power than a Coddington. Fig. 1 exhibits an arrangement of prisms, set upon rays of which two were longer than the remaining four. I have only once since met with this arrangement.

Fig. 3 was small and intensely glistening. Fig. 2 is composed of two distinct figures, of which the second or intermediate is the more simple; I met with each singly more than once during the morning.

Towards the afternoon, this class of figures was exchanged for others of an arborescent character, the six-sided laminæ, however, still continuing to fall, but more sparingly. At long past midnight when I went out of doors, the crystals sparkled in the snow, like mica in a piece of granite, and every cobweb, every leaf, and knotty projection was laden with countless myriads of crystals, which seemed to defy every effort to individualize their character, or group them into classes.

On February 13, I made further observations. Fig. 4 is the only drawing I have yet completed of the several which fell on this day. Its diameter was about 0·05-inch. It glistened brightly, and was highly crystalline. Its general effect was similar to the drawing, and the clusters of prisms round the outer boundary of the figure chiefly arrested the attention; the nucleus appeared a glistening speck.

February 16 afforded me another opportunity of continuing my observations. The minimum of the preceding night had been 23°, at 9 o'clock the temperature in air was 25°, and the maximum for the day was 33·8°. The arborescent form chiefly prevailed.

Figs. 5, 6, 7, are well illustrative of their class, of which they are among the most simple types that could be selected. In figs. 5 and 7, the nucleii, it will be perceived, are prisms set around the centre, with great formality of arrangement; the spiculæ are surmounted with leaves; these, for the most part, are serrated and slightly curved, and are set upon the main radii, at the same angle (that is 60°) with that of the prisms, with which, in figs. 6, 7 they are intermingled.

Fig. 6 is well illustrative of an intermediate stage of

crystallization; three of its prisms, it will be perceived, are in a more advanced stage of formation than the other three. Sir Edward Belcher informs me that he intends to adopt this as an example of intermediate crystalline formation in his appendix to the work he is now preparing on the meteorology of the Arctic seas.

On February 17, there fell an inconceivable variety of crystals, at times accompanied with light snow, but, for the most part, alone. The minimum of the preceding night was 18°, the temperature at 9h. was 22°, and the maximum of the day was 33°. Figs. 8 to 15 are some among the large number that I was able to sketch at intervals throughout the whole of the day. Figs. 8 and 9 were very minute, but exhibited, as seen through a Coddington, a considerable degree of solidity, the prisms being either cubes, hexagonal, or cut with many facets. I sketched nearly twenty varieties on this day, and was surprised at their similarity; they were evidently formations under nearly identical conditions.

On February 21, I was fortunate enough to secure some good observations of double crystals. I had observed many previously, but had not before been in a condition to record them with success. The minimum of the preceding night was 20·9°, the temperature at 9h. was 21°, and the maximum for the day was 30·2°.

I particularly noticed the two specimens, figs. 16 and 17, which were at least 0·4-inch in diameter, and were composed of solid prisms grouped around the radii of the crystal. I have endeavoured to communicate solidity to these figures, which struck me as being intensely beautiful and rich in point of effect. I should, perhaps, mention, in the event of the drawings not sufficiently explaining themselves, that a double crystal is that in which two crystals are united by an axis at right angles to the plane of each. The rays of the under crystal most frequently fell intermediate between, and a little projected beyond those of the upper.

I have yet to speak of an order of crystals, more complex and exhibiting a more graceful arrangement than any I have yet shown to you. I refer to those which combine laminæ and prisms with the leafy or arborescent formation. I am indebted for drawings of two specimens of this class to a lady of my acquaintance, Mrs. King, who, it will be remembered by the readers of the 'Illustrated London News,' on a former occasion, kindly supplied to me the fruit of her observation. (See fig. 8.)

The first to which I shall refer is as graceful a combination as can possibly be imagined, and exhibits a nucleus com-

posed of two hexagons, so centred as to present a double set of angles ; from six of these spring the main radii of the figure, surmounted by crystalline plates or laminæ of (Mrs. King informs me) the greatest transparency. From these laminæ spring leafy tufts, which as it were, crown the structure. The lower part of the ray, near the nucleus, serves as an axis for an elongated prism, near the apex of which spring on either side, leaflets of graceful form. Intermediate, and springing from the angles of the under hexagon, are a set of shorter rays, the axes of similarly elongated prisms, surmounted on the top by three others, the one of similar, the other two of dissimilar figures. It is hardly possible to imagine a more graceful composition, which is greatly enhanced by the delicacy and admirable execution of the drawing.

The one to which I now refer, is also drawn by Mrs. King, and, like the other, was observed under a microscope. It is composed of leaflets and laminæ, and its nucleus is a single hexagonal star. It is less elaborate, but scarcely less graceful than the former. The drawing of the figure claims equal merit with the preceding. I am greatly indebted to Mrs. King for having two such graceful and elaborate specimens to add to the several which I have received from various sources, and which claim no competition with them, in regard to the grace and intricacy of their structural details.

The last morning of the frost presented me with the means of accurately observing a few more facts in connexion with this most interesting subject. When I commenced observing at 9h., the temperature was a little above 32°. A fine snow was then falling, accompanied with thick snowy, ill-defined figures, such as are frequently to be met with at the commencement of a thaw. I examined several of these with my Coddington, and found them to consist of an assemblage of short, half-formed prisms, set on and around a nucleus, at various angles. The prisms themselves were hardly angular, were of irregular length, and notched here and there. With these figures fell innumerable spiculæ, which, under the glass, resolved themselves into prisms, with blunted angles, which had much the character of the icicle, and terminated in a spike. They fell singly, and were of variable length. To the naked eye they appeared of snowy consistency, but under the glass of crystalline transparency. The temperature was rapidly ascending.

After a while, these figures almost entirely disappeared, but a leaf-like pinna was here and there to be detected: a remarkable calm and silence pervaded the air. At 11 o'clock,

with a still ascending temperature, the snow was replete with simple, stellated forms, chiefly of laminæ. Double crystals were very numerous, and I secured sketches of several which I have not yet had time to complete. Fig. 18 represents a double crystal of the prevailing character. I am also again indebted to Mrs. King for another very beautiful and characteristic figure, which she observed on this morning; the minute sets of markings around the edge, have reference to a frosted effect, which communicated additional beauty to the original.

Owing to the high temperature, the figure of the crystals continued rapidly to change; collapsing in the most curious and kaleidoscope manner possible, the upper groups of prisms collapsing first, the next in order next, and so on. When I say collapsing, I mean the sudden dissolving of three or more prisms into one, a change effected with instantaneous rapidity. The next stage of dissolution was the rounding of every angle that remained, and the next stage to that, the thickening and elongation of spiculæ, which had served as axes to the prisms, and which derived accession from the dissolving and half-fluid matter of the prisms.

In this manner they continued to exchange one simple form for another still more simple, until the pristine drop of water occupied the site of the former crystal.

Whilst sketching fig. 18, I saw it undergo a variety of changes, until the several groups of prisms, of which it was composed, collapsed into the figure before you, when every trace of inner markings had disappeared, and the crystal remained of a watery transparency, until it finally dissolved. Figs. 19 and 20 are specimens in a partially dissolving state. From fig. 20, the upper prisms have all but disappeared; and in fig. 19 midway up the pinnæ it will be perceived that some of the prisms have already dissolved, and given place to an irregular and serrated spike, which somewhat impairs the original harmony of the figure.

At noon the snow had all but ceased. The temperature attained to 37°. Cocks crew as anticipating a change; the birds, which for six weeks previously had been silent, answered each other from the trees; icicles two feet in length, which I had noted for sixteen days previously, were fast melting away: all nature but the birds seemed motionless, as waiting the advent of a change; and, what is rarely seen, the trees were dripping moisture while the snow lay like a rime upon their branches and bended stems. Half an hour after, the thermometer rose to 38°, and a complete thaw set in.

At 2 o'clock, the thermometer was 35·5°, small and fine

snow was falling, water was dripping everywhere, the birds were singing joyously, and a dead calm prevailed.

I am not prepared at the present time to enter into any discussion respecting the circumstances of these formations. They involve, I have reason to believe, very compound conditions. As anything that I could say at the present time would require the confirmation of repeated observations and experiment, I am prepared to follow out the investigation as far as possible, and to defer all conclusions for the present.

An INVESTIGATION *into the* STRUCTURE *of the* TORBANEHILL MINERAL, *and of various kinds of* COAL. By JOHN HUGHES BENNETT, M.D., F.R.S.E., Professor of the Institutes of Medicine in the University of Edinburgh. (From the Transactions of the Royal Society at Edinburgh.)

THE investigation, of which I am now about to give an account, was undertaken with the view of determining whether the structure of the Torbanehill mineral was similar to or unlike that of coal. I was aware that the subject would be brought before a court of law, and that many scientific persons of great eminence had already spent much time in the inquiry. With the understanding, therefore, that my evidence, should it be required, was to be limited to the structure of coal and of the mineral in question, I gave directions to Mr. Bryson, the optician, of this city, to make thin sections of attested specimens of various coals and of the mineral, conceiving that a careful examination of them would easily determine the point. It was soon apparent, however, that a far more extended series of researches was necessary than I at first anticipated; but as it was also evident, from the marked structural differences which were observed in the sections, that the investigation would not be destitute of positive results, I determined on pursuing it to a conclusion.

The plan adopted was, in the first instance, to make myself familiar with the structure of the ordinary household coals used in this city, of which those called the Zetland and the Dalkeith or Buccleuch coals may be considered as the types. I then examined the structure of the Wallsend, Newcastle, and various other kinds of household coal, in every case observing, with magnifying powers of various diameters, thin sections made horizontally and longitudinally with the line of stratification. I next examined similarly-made thin sections of the Torbanehill mineral, and was struck with the remarkable dissimilarity which existed between them. I now had

numerous sections prepared of various cannel coals, and having previously determined the appearances presented by true coal and by the mineral, I was readily enabled to distinguish the various shades of differences between them. I saw that although the cannel coals, and especially one of them, the Brown Methil, approached in structural character to that of the Torbanehill mineral, it could still be distinguished from it by a practised eye; and that although gradations existed between these different substances, there was at least one element which served readily to characterize all the different kinds of coal I had hitherto examined, and which was not present in the mineral. I now went over the sections of coal in the rich collection of Mr. Alexander Bryson of this city, and subsequently carefully examined the numerous sections made by Dr. Adams of Glasgow. Before the trial of Gillespie *versus* Russel came on, Dr Adams, Mr. Quekett, and myself, spent nearly an entire day together, examining each other's specimens, and carefully reinvestigating the whole subject. It was then that the character of the ashes in the various substances we had examined was pointed out to me by Dr. Adams, who, in my opinion, is entitled to the greatest credit for the laborious, skilful, and successful efforts he has made in determining the structure of numerous coals, and pointing out the differences they exhibited, when compared with the Torbanehill mineral. At this meeting, also, we compared the structure of coal with various kinds of recent woods; we incinerated the mineral and certain coals, and carefully examined the ashes; and there was established, as the result of this conjoined investigation, as well as from the independent researches made by Dr. Adams in Glasgow, by Mr. Quekett in London, and by myself in Edinburgh, the most perfect accord with regard to all the facts which had been elicited during the inquiry.

At the commencement of the present session, I brought the subject under the notice of the Physiological Society of this city, who appointed a committee, composed of four gentlemen in addition to myself, all of whom had long been accustomed to the use of the microscope, and were familiar with vegetable and animal structures. Three of these gentlemen, viz., Dr. Cobbold, and Messrs. Barlow and Kirk, made farther inquiries and researches, which served to elicit additional facts, and to demonstrate, in the language of their report, that "the Torbanehill mineral is widely different from every kind of coal." Lastly, with a view of meeting certain theoretical objections which have been advanced, I have carefully examined the structure of various kinds of peat, as well as the stems of recent ferns and several fossil plants, which have only served to

establish the entire absence of connexion between these substances and the Torbanehill mineral.

In now endeavouring to place in a condensed form the results of this extended investigation before the Society, I propose, in the first place, to describe the facts, as they may be easily demonstrated in the field of the microscope. Secondly, to deduce from these facts the structural element which distinguishes every kind of coal from the Torbanehill mineral, and explain the cause of the differences which are recorded in the proceedings of the recent trial. Lastly, to offer a few speculations as to the nature of this mineral, as distinguished from various kinds of household and cannel coals.

I. When we examine a piece of undoubted coal, such as of the Zetland or Buccleuch coals, it presents to the naked eye a fibrous structure, and has a black shining streak. It has been found difficult to make thin sections of it, as in the grinding process it readily crumbles down. But when a tolerably thin slice, made in the direction of the fibres, is with great pains obtained, and examined with a magnifying power of 200 diameters linear, it is then also seen to possess a fibrous structure. These fibres may be observed to be composed of a reddish-brown coloured substance, in the centre of which is sometimes a dark streak. Oval and elongated transparent masses of a light yellow or reddish-brown colour may also be seen running parallel with the fibres, and here and there are colourless spaces, which strongly reflect light, and which are evidently filled with a crystalline mineral substance.

On examining a section horizontal to the former one, parallel with the plane of stratification, a bistre-brown or blackish opaque mass is seen, containing a number of rings of a transparent yellowish or reddish colour, with an opaque centre. These rings are from the 1000th to the 1500th of an inch in diameter, and resemble the transverse sections of tubes running at right angles to the fibres of the coal. There may also be observed larger masses of a reddish-brown transparent material, varying in size from the $\frac{1}{6}$th to the $\frac{1}{200}$th of an inch in diameter. There are also visible, circles or rings of a rich golden yellow matter, much larger, and varying in size from the 50th to the 6th of an inch, which have been described by some as seeds or spore cases.

Similar appearances may be observed in the Wallsend, Newcastle, and all the other household coals I have examined, although in some of them, especially Newcastle coal, this structure is more obscured, than in the Scotch coal, by dense black opaque matter. Here and there, however, in the Newcastle as well as in the Hamilton and some other coals, it may

be found to present a highly fibrous fracture, minute chips of which exhibit at their edges distinctly dotted or porous ducts.

On examining the Torbanehill mineral with the naked eye, it is destitute of a fibrous structure, and presents a homogeneous appearance in whatever way it is fractured or cut. It is tough and hard to break, when compared with coal, has a dull brown streak, and is readily ground down into thin slices of any degree of tenuity. Some specimens are of a dark, and others of a light brown colour. The section of a dark specimen seen under a magnifying power of 200 diameters, presents, first, a number of yellowish and reddish-brown transparent masses, of a rounded form with an irregular outline, varying in size from the $\frac{1}{4000}$th to the $\frac{1}{200}$th of an inch in diameter. These are surrounded by a dark opaque substance, in which they appear to be imbedded, and in which no trace of structure can be detected. These light and dark substances vary in relative amount in different specimens of the mineral, and according to the thickness of the section. In some specimens, the rounded transparent masses are more widely separated by the opaque substance, but in others, they are often so close, that a very thin section presents a homogeneous appearance of yellowish or reddish-yellow matter, resembling bees-wax, with only a few irregular spots of the black matter. In some sections, especially of the light-brown specimens, the rounded masses, as they are ground thinner, may be seen, as it were, to melt into one another. In such sections, no difference whatever can be made out, whether they be made in a longitudinal or in a horizontal direction.

In some thin sections, these rounded transparent bodies can be separated from one another, and be distinctly seen to possess a radiated crystalline appearance, strongly reminding one of the crystals of carbonate of lime which occur in urine. At certain angles, also, a few of them refract light, and become strongly tinted with the orange ray when polarized,—a circumstance perhaps dependent on the admixture of mineral matter. When a section of the mineral, presenting both the substances described, is held over the flame of a lamp, the yellow matter evaporates in the form of thick smoke, leaving the black matter unaffected, with large holes or loculi in it. It must be clear from this experiment that the yellow matter is some bituminous or resinous substance, easily decomposed by the heat of a lamp, and that the black matter is an earthy material, which resists the same amount of heat. We can have no doubt, therefore, that an easily volatilized and highly inflammable matter has concreted in the form of rounded masses, and constitutes the light-coloured portion of the mi-

neral formerly described. Whether this be chemically the same as, or only allied to bitumen, resin, or amber, I leave to be determined by chemists. But we may at least correctly denominate it a *Bituminoid* substance, that is, one which closely resembles, even should it turn out not to be identical with bitumen. The matter in which this is imbedded seems for the most part to be composed of clay, or earthy matter which leaves a white ash, altogether destitute of structural traces, and is equally amorphous in whatever direction the section of the mineral is examined.

Some portion of the Torbanehill mineral, however, has a tendency to split up into thin laminæ, and presents smooth or irregular depressions, dependent on the presence of *Stigmaria* or other fossil plants, which, in these places, come in contact with, or are imbedded in, the substance of the mineral. Thin sections of such portions exhibit masses of a rich-brown colour, composed of scalariform ducts in great numbers, and occasionally the woody fibres and rings of coal. These latter are most common where the mineral forms a junction with coal, and where the one is more or less mingled, or alternates with the other. In these places the great difference in structure between them is easily recognised both by the naked eye, and by microscopic demonstration. By the naked eye, the black shining layers of coal are easily distinguished from the brown dull appearance of the mineral, and wherever such coal exists, the streak is dark and lustrous; wherever the Torbanehill mineral is pure, and unmixed with vegetable matter, it exhibits the dull-brown streak. In such places, the mineral is characterized, under the microscope, by its yellow masses and black basis; the coal, by its rich-brown fibrous structure. Occasionally sections at the point of junction, prove that the scalariform tissue, like the substance of coal, is very friable and easily broken down. This fact, which was pointed out to me by Mr. Kirk, induced him to think that the amorphous basis might be composed of such tissue disintegrated, a supposition negatived by the absence of all trace of structure through the mineral generally.

From what has been said it must be evident, that there is a wide distinction between all kinds of household coal and the Torbanehill mineral; and the correct discrimination between the fibrous, woody texture of the one, and the granular bituminoid, and earthy substance of the latter, will enable us to understand the more confused texture presented in certain cannel coals, which it has been contended are identical in structure with the mineral.

I have examined a large number of cannel coals, and in

every case have been enabled to recognise the fibrous structure of the longitudinal section, and the appearance of rings in the transverse sections, as they are seen in household coal. They contain, however, a greater or less number of the bituminoid masses, identical with those which constitute the principal substance of the Torbanehill mineral.

The Capeldrae and brown Methil coals are especially rich in these bituminoid bodies, and in consequence have been regarded as identical in structure with the mineral. In some sections of the latter coal, they are almost as numerous as those in the dark specimens of the Torbanehill mineral; but a careful examination will show that it also possesses the same organic structure as coal, and may be at once distinguished by its reddish fibres, when cut in one direction, and by the distinct rings, though few in number, observed on a transverse section.

I consider that this proof of structure in the brown Methil coal, is decisive of the question as to the distinction between coal and the Torbanehill mineral. Every one allows, that of all the cannel coals, the brown Methil is the one which most closely resembles it. It has also been reported that no difference can be detected between them by the aid of magnifying glasses. To this I may reply, that I have always been able to distinguish them at once; that I have never been deceived in doing so, although the attempt has often been made; nor do I believe that any histologist who has made himself acquainted with the structure of coal on the one hand, and of the Torbanehill mineral on the other, could easily confound the two together.

There are two other modes of examination which also indicate the broad distinction in structure between coal and the mineral. These are by reducing them to powder and to an ash.

The powder of household coal contains numerous short black fibres, separated or aggregated together, mingled with mineral particles and fragments of cells. That of the Torbanehill mineral is composed of transparent yellowish masses, evidently the same as those seen in section, but more broken up, and without any trace of an envelope, mingled with fragments and the debris of the dark amorphous mineral matter. This mode of examination, though distinctive between the household coals and the mineral, is not so much so, when the brown Methil coal is chosen as the subject of comparison.

An examination of the ash, however, is still more characteristic. In the brown or blackish ashes of coals will be found, 1st, A greater or less number of mineral spicula, evidently the skeletons of the woody fibre; 2nd, Siliceous masses of various irregular forms, obtained from the interstices of the

organic substance ; 3rd, Black fibres, separated or in masses, evidently the woody fibre carbonized ; 4th, Flat carbonaceous plates, presenting round apertures corresponding in size to the woody cells which passed through them, and exhibiting at their margins sections of larger circles, which doubtless bounded the large resin cells in the recent wood. None of these appearances are visible in the ash of the Torbanehill mineral, when care is taken to exclude such portions of it as are free from the stigmaria or other plants imbedded in it. Indeed I myself have never seen such appearances in the ash, even when no such precaution has been taken. Dr. George Wilson gave me a considerable quantity of it, which everywhere exhibited nothing but an amorphous material, such as might result from the incineration of clay or other earthy non-organic substance. In all the cannel coals, traces of these forms, though not so numerous or abundant, can be seen. Mr. Quekett has even applied this test to Welsh anthracite, in which substance no rings or fibrous structure can be made out in sections, yet where, he says, the ash gives unmistakable evidence of the presence of woody tissue.*

II. Such, then, are the facts which an investigation into the structure of coals on the one hand, and of the Torbanehill mineral on the other, has elicited. If the account I have given of them be correct, it must be evident that the differences they present are marked and distinctive ; that the one is essentially a woody structure, whilst the other is not. Every kind of coal, including the brown Methil, may be at once distinguished from the Torbanehill mineral, by the rings contained in a well-made transverse section. I further contend that such an appearance constitutes, in the majority of cases, a practical and evident test, distinctive of genuine coal, and that by means of it all kinds of known coal, whether household or cannel, can at once be distinguished from the Torbanehill mineral.

Now if this be the case, it may well be asked how it happened that, at the late celebrated trial, so many persons, all of whom represented themselves as being skilful observers with the microscope, should have been made to give diametrically opposite evidence, not only as to matters of opinion, but as to what appeared to be matters of fact? In endeavouring to place the remarkable histological controversy which has originated out of the trial of Gillespie *versus* Russel on its correct basis, it must be remembered that unquestionable organic structure is only present in the Torbanehill mineral at certain places. No one, for instance, can doubt that the scalariform ducts seen by all parties are of vegetable origin ; but it is no-

* 'Quarterly Journal of Microscopical Science,' No. VI., p. 43.

where pretended that these were everywhere present in the mineral. It is of great importance, therefore, not to confound the organic plants imbedded in a substance with the substance itself. The occurrence of Stigmaria or other vegetable remains in coal, or in the Torbanehill mineral, no more constitute those substances coal, than they convert sandstone and limestone into coal, in both which rocks they are also found. Nor do I imagine it can be generally maintained that because animal substances, such as teeth, jaw-bones, or the skeletons of fishes and lizards, are occasionally found imbedded in stone, that therefore they form an essential and necessary part of the stone itself. At the trial, great amount of confusion resulted from not keeping this distinction clearly in view.

Thus when Mr. Quekett stated that all that which may be supposed like vegetable structure in the Torbanehill mineral disappears when the structure is thin, he was asked by the Dean of Faculty, "When you speak of that which appears as vegetable structure, you mean those isolated fossil plants?" to which Mr. Quekett unfortunately answered, "Yes;" for what he really meant was, not the isolated imbedded plants, but the structure of the mineral itself. In consequence, the counsel for the pursuer and for the defender truly played at cross-purposes throughout the whole of the structural evidence; for, notwithstanding the clearness of Dr. Balfour's statement, he was asked, after saying that the mineral consists of a plant, whether he had seen fossil plants in stone? to which he answered, Yes. But then being asked whether he considered that an example of such an appearance, he very correctly, according to his views, answered, No.

From the published report of the trial, however, by Mr. Lyell, it is evident that the eminent gentlemen who contended that the Torbanehill mineral was a vegetable substance abounding in cells, did not adopt this idea because various plants were imbedded in it, but because they believed the clear rounded masses I have described were themselves vegetable cells. Unfortunately, the possibility of this theory being adopted had not been anticipated, nor was it perceived by the counsel for the pursuer. In consequence, the witnesses on the one side were made to declare that the Torbanehill mineral was not vegetable, and on the other that it was, without the true reason of this discrepancy ever having been made to appear.

Dr. Balfour stated in court, that he believed the yellow part of the Torbanehill mineral to consist of vegetable cells; that it was not the mere impression of a foreign fossil, but the

actual structure of the mineral at that place.* In the same manner Dr. Redfern, when asked,† "What do you think these yellow spots indicate?" replied, "They indicate the existence of vegetable cells." The reasons he gave for so considering them were, "That they can be perfectly isolated —they project upon the edges of all sections of the mineral— they are rounded—they are as uniform in size as the cells of other vegetable structures—the general appearance of the section is that of a piece of vegetable cellular tissue—the yellow spots do not act upon polarized light, or act upon it very feebly."

Dr. Greville, also, speaking of the same bodies, said,‡ that "he had no more doubt of their being vegetable cells than he had of his own existence;" that "in one specimen it was so unequivocally marked, and so regular, that it might be compared to that of a recent plant;" and that "no person accustomed to botanical sections would hesitate in believing it to be cellular tissue."

From these quotations it must be evident that both parties saw the same things, but that while on one side it was contended that they were not vegetable cells, but bituminoid masses imbedded in clay, on the other it was strongly asseverated, in the language I have quoted, that *because* they were vegetable cells, therefore the Torbanehill mineral was a fossil plant. But in consequence of the reason of this difference in opinion not having been distinctly brought out in examination, the greatest confusion seemed to prevail in the minds of judge, counsel, and jury; and it was thought that the witnesses for the defender being skilful botanists, were enabled to see what the witnesses for the pursuers did not see. This result, as well as the confusion occasioned by the examination of the witnesses, is evident from the observations made by the learned Judge to the jury, from which I shall take the liberty of quoting:—

"One general remark may be made on the microscopic testimony, and it is, that there are those who see a thing, and also those who do not see it—those who do see it, cannot see it unless it is there, and those who cannot see it do not see it at all. But very skilful persons looking for a thing and not seeing it, creates a strong presumption that it is not there. But when other persons do find it, it goes far to displace the notion that it is not there. But there is another observation on the microscopic evidence that occurred to me. I do not know whether I am under any misapprehension, but I think

* Mr. Lyell's Report, pp. 168-9. † Ibid., p. 170.
‡ Ibid., pp. 171-2.

that three, certainly two, of those examined by the defenders are botanists also; and I do not think that any of those examined for the pursuer, three of them from London, represented themselves as botanists. Now the defenders' witnesses are accustomed to look for plants, and can understand them when they see them. The gentlemen on the other side, again, looking for woody fibre or tissue, are not, as I understand, conversant or skilful in fossil plants."*

Now, so far from the botanists seeing what the histologists did not see, it is nowhere made to appear in their evidence that they ever observed those rings on a transverse section, which I have endeavoured to show are distinctive of true coal. On the contrary, they contended that coal and the Torbanehill mineral were similar in structure, the elements of the one existing in the other, both containing vegetable cells; that the numerous yellow clear masses observed in the latter were in point of fact such cells, and constituted the proof of vegetable organization.

I think it of great importance to rescue the mode of investigation by means of the microscope from all reproach in this case, and to point out that the discrepancy which existed is not one of fact, but one of inference. I hope then it will be evident that the true scientific controversy is altogether connected with the question of whether these yellow masses, which both parties saw, described, and figured, are or are not vegetable cells.

Now the view taken up by myself from the first, and which was also taken up by Dr. Adams and Mr. Quekett, independently of each other, was that they are not cells, but masses of a concrete bituminoid or resinoid substance, imbedded in earthy matter. We could nowhere discover in them any trace of cell-wall or contents. Their mode of fracture was more crystalline in its character than anything else; they occurred confusedly together, and nowhere presented that definite arrangement to one another, or to ducts and woody tissue, which exists in plants. Numbers of them present no envelope or definite boundary, but are scattered through a substance often more than two feet deep, extending for acres, and it may be for miles. If these yellow masses be cells, what is their origin? They cannot come from the woody tissue of the neighbouring coal, for, as we have endeavoured to show, such coal is destitute of them. The rings in coal are much smaller in diameter, are of regular size, and present the character of a tube cut transversely. Such rings could never be confounded with the yellow masses of the mineral. But supposing these

* Mr. Lyell's Report, pp. 238-9.

latter to be cells, could such multitudes of them be derived from the gigantic ferns of the coal formation, or such as are imbedded in the mineral? I think not; because the amount of scalariform and woody tissue is too disproportioned to the number of the cells to favour such an idea. Besides, what kind of force or power could have been in operation that would have separated and collected the delicate cells, and left the ducts and other tissues of the plants by themselves, and out of sight throughout such enormous masses. I have carefully examined the cells in large ferns, and observed the singular markings of cellular tissue, woody fibre, and scalariform ducts, many of them present, visible even to the naked eye,—than which nothing can be more unlike the Torbanehill mineral. The cells themselves are also larger, of more uniform size, and contain numerous starch granules; whilst the true resin cells are exceedingly large and distinct, strongly analogous, indeed, to what I have described as existing in the woody texture of coal, but wholly dissimilar to anything observable in the Torbanehill mineral. Such a view, indeed, would, it seems to me, lead to the extraordinary conclusion that this mineral is composed of a vegetable tissue, more cellular than any plant ever yet met with, recent or fossil, and so rich in cells as to be wholly dissimilar to what we can even imagine to have existed, taking its size and bulk into consideration. Such masses of cells could not have been formed or nourished without ducts passing through them, in various definite directions, to convey a nutritive fluid; and yet we find such ducts only to be accidental, and only distinctly connected with plants imbedded here and there in the general mass.

Whilst, then, the notion of these yellow masses being vegetable cells, seems to me opposed to every known or conceivable fact yet ascertained to exist in vegetable histology, or from such as are demonstrable in the Torbanehill mineral, the theory of their being bituminoid masses imbedded in clay, appears to be in perfect harmony with all of them, and especially answers the reasons given by Dr. Redfern.

With a view of determining whether the Torbanehill mineral could by any possibility be produced by a process similar to that of the formation of peat, which was described at the last meeting of the Society by Dr. Fleming,* I have examined various specimens of peat, and have confirmed his description. They consist of mosses, especially of the Sphagnum, the spiral cells of which plant are peculiar, and easily recognised, associated with broken-down woody tissue, root-stalks, and

* Proceedings of the Royal Society of Edinburgh. Session 1853-4, p. 216.

bundles of simple ducts, more or less carbonized and condensed together. The deeper the peat is taken from the bog, the more condensed, broken up, and altered these textures are; still, however, sufficiently retaining their characters to be readily distinguishable. The peat of Scotland between this and Glasgow, and that of the north of Ireland, of which I have examined numerous specimens, taken from mountain bog, as well as the flow bog, are identical in structure. One specimen of peat, however, given to me by Dr. Traill, which he obtained in Lancashire, and which answers in description to what is called Pitch Peat, is blacker in colour, the carbonizing process is more complete, and the vegetable tissues less distinct. But here and there, in a thin section of this peat, there exist rounded masses of the same bituminoid character as are found in the cannel coals and in the Torbanehill mineral. This fact confirms the theory formerly advanced, that these bodies are not cells, but a concrete bituminoid substance, probably derived from the beds of coal in Lancashire, in the immediate neighbourhood of the peat.

We may therefore conclude that every kind of coal has a distinctly woody basis, which is easily demonstrated by its longitudinal and transverse sections; that the cannel coals have, in addition to this woody structure, a greater or less number of the bituminoid masses imbedded in it; and that the Torbanehill mineral has no such woody texture, but is essentially composed of the bituminoid masses imbedded in clay.

III. In the third place, the theory which I am disposed to put forward as most in harmony with the various facts and arguments previously stated, is as follows:—1st, That the various organic appearances found in the sections and ashes of coal are explicable by the supposition that coal is wood chemically altered, and for the most part coniferous wood, or wood allied to it in structure, because, from a careful comparison of recent fir-wood with the various kinds of coal, I find the structural appearances of the cellular tissue, resin cells, and ducts, to be very similar. Further, no fir-wood growing in this country contains spiral ducts; and it is remarkable that no traces of such ducts are to be found in any of the coals I have examined. Further, the assumption that coal is formed from fir or allied woods, not only explains its structure, but accounts for the large amount of bitumen, resin, or inflammable matter it contains, resin being a well-known abundant product of the coniferous tribe of plants.*

* In the above passage, I have carefully avoided any expression which would suggest the notion that in my opinion the wood from which coal is formed, is *exclusively* coniferous wood. I believe that, with regard to the

2nd, The Torbanehill mineral, although it presents essentially no traces of vegetable structure, is rich in the bituminoid substance;—a circumstance, I think, explained by the fact that it is found in the neighbourhood of coal, so that the bituminoid or resinoid matter formed in the partially-woody structure of the latter has flowed out, mixed itself with, and solidified in the essentially earthy substance of the former. It is easy to conceive how enormous pressure, conjoined with chemical change and heat, may have effected this, and how sometimes such fluid bituminoid matter may have run into neighbouring beds of peat, of clay, or even of sandstone. Facts, indeed, are not wanting to show that occasionally large collections of such substance, almost pure, may be formed, unmixed with either peat or clay, of which the remarkable specimen I now exhibit to the Society, taken from the Binnie Quarry, and for which I am indebted to Dr. Christison, is an example. Fragments of this substance, under the microscope, closely resemble the yellow masses which exist in the Torbanehill mineral.

In conclusion, I would remark that the controversy on this subject is only an example of a far more extensive one which is now everywhere taking place throughout the natural sciences, in reference to the influence which more improved methods of research in chemistry and histology should exercise on our thoughts and nomenclature. Those who, with myself, recognise that differences in structure indicate differences in function, and that these should be studied as the foundation for a correct classification, will recognise in the question, what is coal? an analogue to the questions, what is wood or coral?—what is bone or tooth?—what is a fibrous or a cancerous tumour? The progress of science, and especially of microchemistry, has already answered some of these questions, and will ultimately determine others; and in doing so, will overthrow the more vague and incorrect views and terms which previously prevailed. At the trial, indeed, it was very plausibly argued, that, in a bargain between man and man, scientific terms were of no value, and that a whale among whalers was still a fish.* But in this Society, as no naturalist, con-

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varieties and even genera of the plants of the coal-formation, there is still much to be discovered. But so far as my examinations have gone, the appearances observed warrant the general inference stated in the text, one which has also been arrived at by Mr. Quekett. ('Mic. Journal,' No. vi., p. 42.) The important fact to be kept in remembrance is, that coal is fossil or transformed wood, whilst the Torbanehill mineral, and all the shales which I have examined, are not.

* Mr. Lyell's Report, p. 231.

versant with the structure and functions of a whale, would for a moment suppose it to be a fish, because it inhabits the water and resembles one; so I contend no histologist, acquainted with the structure and properties of the Torbanehill mineral, ought to maintain that it is coal, because it is dug out of the earth and burns in the fire.

TRANSLATIONS.

Observations *on* Noctiluca (*miliaris?*). By Dr. W. Busch.*

The following observations upon the structure and reproduction of a species of *Noctiluca* were made by Dr. Busch in the year 1849, and will be found in his work cited below, which was published in 1851. With respect to the structure of the animal, they perhaps present nothing in addition to what has already been made known to our readers in the Papers by Mr. Huxley and by Dr. Webb, in the present Volume of the 'Journal;' but as regards the reproduction and development of the *Noctiluca*, they afford several new points, and it is for that reason that we have thought it might be useful here to introduce them, and the more so, as it would seem these remarks by Dr. Busch had escaped the notice of Krohn,† as well as of Mr. Huxley ‡ and Dr. Webb.§ The species noticed by Dr. Busch occurred in great abundance in the Bay of Malaga, and is regarded by him, but we think, perhaps, erroneously, as distinct from *N. miliaris*. He terms it *N. punctata*, from the circumstance that the integument was covered with very numerous minute pigment-points; but the resemblance of his figure to *N. miliaris* is so striking, and the structure, so far as he describes it, so closely identical with that of the latter, that no doubt can be entertained as to the identity of the two forms.

"These animals, as is well known, consist of a rounded disc of a gelatinous consistence, like that of the Medusæ. At the upper part (fig. 1, *a*, Pl. X., Mic. Jour.), the borders are curved inwards and downwards, so that, whilst on the under side the contour is continued uninterruptedly, a sort of *hilus* is formed above, from the middle of which a straight, sharp-bordered rod, *b*, extends directly inwards and downwards, being prolonged into an acute point. At the point where the above-mentioned curved borders meet is situated a brown, round body, *c* [nucleus], from which numerous branched fibres extend towards the periphery. The solitary motile organ of the animal arises from about the same point. This is a band-like filament, *d*, about as long as the diameter of the body of the creature, and exhibiting numerous transverse lines, which give it a striated appearance, but never extend across the entire width of the filament. The

* Abstracted from 'Beobachtung. üb. Anat. u. Entwickl. einiger wirbellosen Seethiere,' p. 103. Berlin, 1851.

† Wiegmann's Archiv., 1852, p. 77.

‡ 'Quarterly Journal of Microscopical Science,' Vol. iii., p. 49.

§ Ibid., p. 102.

animal moves this sort of *proboscis* slowly backwards and forwards. Opinions are much divided as to whether an opening, or sort of mouth, exists in this *hilus*, or whether the creature is unfurnished with such an organ."

Though he has not seen it, the author believes there must be an entrance.

"From the few data," he goes on to say, "afforded by the study of the development of this curious creature, it may, however, be shown that an inversion or invagination takes place in this situation, and consequently that an entrance must exist.

"As regards the interior of the disc; in some individuals it was perfectly empty, but in others, several brown bodies existed, as seen in fig. 1 *f*, sometimes of a rounded, sometimes of an oval or hour-glass shape. Occasionally they were in such close apposition with the nucleiform body, that the latter appeared to be continued into them; but they might also be noticed perfectly free in the interior. The structure of these bodies is shown in fig. 8: it represents a cell with homogeneous walls, and containing a large, coarsely granular *nucleus*. Among numerous perfect *Noctilucæ*, some were met with composed apparently of nothing but an empty membrane, and whose true nature could only be recognised from the presence of the *proboscis*. In the interior of these sacs were found minute corpuscles, such as are represented in fig. 2; viz., oval discs, with a *nucleus* occupying nearly the whole interior. The colour of these bodies corresponded with that of the minute globular bodies, which were noticed in the interior of the old *Noctilucæ*, but from which they were distinguished by the homogeneity of the substance of the *nucleus*. Occasionally, though more rarely than the above, these sacs contained germs somewhat farther advanced in their development (fig. 3). The most important change apparent in these is the existence of a process as yet obtuse. These bodies occurred more abundantly in the free state, swimming about among the other *Noctilucæ*, than those contained in the *sacculi*; and their farther development was observed to take place as follows. The obtuse process becomes pointed, and on its side is formed a minute appendage, arising from the opaque *nucleus*, and resembling in structure and relations the proboscis of the adult animal (fig. 4). It is thence evident that the *nucleus* represents the brown nodule in the *hilus* of the mature *Noctiluca*, and that the motile filament arises from it. It might now be expected that the round disc simply increased in size, and that the other organs were developed in its interior; but it would appear that the entire organism is subjected to remarkable transformations before this result is attained to. As the disc increases in size, the pointed process becomes elongated outwardly (figs. 5 and 6); and in its interior appears a structure resembling the 'rod' which we have described as existing in the *Noctiluca*; but the direction of the rod at this time is exactly the reverse of that in which it is placed in the adult animal. For whilst in the latter, starting from the brown nodular body, it stretches towards the periphery of the disc farthest from the *nucleus*, in the former it projects straight out from it.

"At the same time also the border of the disc loses its evenness, and acquires angular processes of the same colour and consistence as the disc itself (figs. 5 and 6). Viewing all these figures, it seems most probable that the form of the large animal is developed out of them in the following way. As the disc continues to grow, the 'rod' must be reverted on itself, and the processes of the disc having at the same time become longer and broader, must close over it and unite. The animal would thus be perfected; and, upon any other supposition, it is not easy to see how the

'rod' should come into the proper position; or what function is performed by the projecting processes."

The full elucidation of this very interesting point was prevented by the interference of the highly enlightened port-officials, who feared that the author's researches in Marine Zoology would be injurious to the interests of the Spanish people.

The fragmentary observations in development made by the author were too scanty, as he considers, to lead to any definite result. "The most important point appears to be to determine whether the genus found in the empty *sacculi* are identical with the brown corpuscles met with in the interior of the old *Noctiluca*. From their size, this might certainly be supposed; but in that case, the originally granular contents of their *nucleus* must be transformed into a homogeneous substance. It is probable, therefore, that the brown bodies, which at first make their appearance on the nodular mass, may be *gemmæ*, which are subsequently detached, and after remaining for a time in the interior, undergo further development." (?)

In fig. 7 is represented an animal apparently referrible to *Noctiluca*, and which might readily be imagined to represent a gemmule fully developed on a perfect *Noctiluca*, which had pullulated on the disc itself, and only required to be detached to become an independent individual. But the author is rather inclined to believe that it is only an abnormity, a double monster; for if a germination of this kind really took place in this class of animals, it would be very remarkable that only a single instance of it should be presented, among the innumerable multitudes of individuals brought under the author's observation.

"Among the *Noctilucæ* taken during the three days," in which he was permitted to continue his researches, "there occurred bodies of another kind still (fig. 9), which, like the *Noctilucæ*, floated on the surface of the water, and were of exactly the same size and consistence, although they presented organs of far smaller dimensions. Some specimens also shone in the dark like the *Noctilucæ*. They were minute gelatinous discs, nearly perfect spheres, quite transparent, without fibres or filament; the greater part of their bulk was entirely homogeneous, except that on a very small segment of the upper surface might be remarked numerous yellowish processes. Most of these processes were rounded, but some had a very fine point, into which they were prolonged above, being attached by a wider base below (fig. 10). The only indication of structure in them were minute round granules. That

these bodies were animal existences, is perhaps indubitable, from their phosphorescence; but in what connexion they stand with respect to the *Noctilucæ*, associated with which they occurred in large number, cannot at present be determined."

Untersuchungen *ueber die* Entwicklungs-geschichte *der* Mikroskopischen Algen *und* Pilze. Von Dr. F. Cohn. (Researches on the Development of the Microscopic Algæ and Fungi. By Dr. F. Cohn; pp. 153; 6 Plates. Bonn, 1854.

The importance of the study of unicellular organisms, as leading in the most ready and complete way to a knowledge of the "cell," the foundation of all scientific acquaintance with the real nature of *plant life* is so obvious, as to have attracted a great number of followers.

The fresh-water Algæ, especially, afford abundant and readily attainable materials for this study, and have, consequently, formed the subjects of numerous writings. Amongst those who have distinguished themselves in this field, the name of Dr. Cohn will ever be held in deserved honour. He has, for many years, as he says, devoted himself to this study; and, especially, to the remarkable propagation of most of these Algæ by means of motile cells (swarm-spores); a mode of reproduction which has been observed in most of the fresh-water species. The same phenomenon has also attracted the attention of numerous other observers, and been the subject of several memoirs. Among the more important of these, exclusive of Dr. Cohn's, may be noticed the observations respecting it contained in Dr. Braun's remarkable work on 'Rejuvenescence in Nature,' of which a translation by Mr. Henfrey has lately been published by the Ray Society; and the 'Recherches sur les Zoospores des Algues et les Anthéridies des Cryptogames' of M. Thuret. The appearance of these independent memoirs appears to have turned Dr. Cohn from his original intention of publishing a special treatise on the 'Swarm-cells of the Algæ,' and to have decided him merely to give separate essays on those points appearing to him to demand further attention; his former monograph on the 'Development of *Chlamydococcus* (*Protococcus*) *pluvialis*,' of which an abstract has also been published by the Ray Society with figures; and his Memoir in Siebold and Kölliker's Zeitschrift f. wiss. Zool. 'On a new genus from the family of the Volvocina,' of which a translation has appeared in the 'Annals of Nat. History,' 2nd series, Vol. x., p. 321,

are the more important of these essays that have yet appeared, and should be attentively studied by all who are desirous of becoming acquainted with the matter.

The present work is, in fact, a collection of shorter essays having more or less direct reference to the same subject, and will be found to contain a vast amount of important and interesting information.

The subjects treated of are—

1. On the relation of the microscopic *Fungi* to the microscopic *Algæ*.
2. On *Chytridium*, and some allied genera.
3. Observations on *Gonium pectorale*, and the Volvocina in general.
4. On the propagation of *Hydrodictyon utriculatum*, together with some remarks on "swarm-cells" in general.
5. On the germination of *Zygnema* and *Anabœna*.

These papers are illustrated by figures of

Anthophysa Mülleri.
Zooglœa (*vibrio*) *termo.*
Spirulina plicatilis (*Spirochæte*, *p.*, Ehr.)
Spirulina Jenneri.
Synedra putrida, n. s.
Chlamydomonas hyalina (*Polytoma uvella*, Ehr.)
Chytridium globosum, A. Braun.
Peronium aviculare, Cohn.
Achlya prolifera.
Spirogyra nitida.
Zygnema stellinum.
Closterium Lunula.
Mougeotia genuflexa?
Anabœna intricata?
Achlya capitulifera.
Chlamydococcus pluvialis.
Gonium pectorale.
Chlamydomonas pulvisculus.
Hydrodictyon utriculatum.
Œdogonium capillare.
Cladophora glomerata (monstrous spores of).

1. On the relations of the microscopic Fungi to the microscopic Algæ.

The result of his study of the lowest forms has led Dr. Cohn to the conclusion, that no sufficient reasons derived from morphological and developmental considerations exist for the separation of the Algæ from the Fungi. Though the distinction between the Thallophytes and Cormophytes of Endlicher is sufficiently definite, the three classes into which the former have, since Linnæus, been subdivided, viz., the Algæ, Fungi, and Lichens, are by no means so well defined as, for instance, the Mosses from the Ferns, or the Equisetaceæ from the Lycopodiaceæ. It would seem as if the multitudinous class of Thallophytes constituted, *organologically*, but a single indivisible kingdom, and that the above three provinces were characterized merely by the more or less developed, and, it must be confessed, widely different *forms*, and in no way by any intrinsic difference of *type* in the vegetative or reproductive organization.

The Algæ, as usually understood, like most other plants, are capable of appropriating, by an innate power, the materials

requisite for the maintenance of their organism, from the elements carbon, oxygen, hydrogen, and nitrogen, and some oxides and salts, which are afforded to them in the surrounding medium, in the form of carbonic acid, ammonia, and water; they do not, therefore, require any organic nutriment, but are enabled to vegetate in pure water; they can decompose the water or the carbonic acid, and evolve oxygen in the sunlight, acquiring at the same time a green or red colour, from the development of chlorophyll or some analogous colouring matter. The Fungi, on the other hand, like animals and most parasitic plants, have not the power of spontaneously producing, from *inorganic* nutriment, the materials requisite for the maintenance of their vital processes—these must be afforded to them in the form of already organized compounds; they cannot, therefore, flourish where this nutriment is not afforded to them, either in a living or in a dead and decaying organism, or at any rate in water in which a considerable amount of organic matter is not dissolved, as in an *infusion;* they evolve no oxygen, and do not become green in the light. Partly, from the latter circumstance, Nägeli distinguishes the Fungi from the Algæ by the want of chlorophyll, or some analogous colouring matter. But that the presence or absence of chlorophyll affords no sufficient character to distinguish the one class from the other, is sufficiently obvious, when we consider the variableness exhibited in this respect, in several classes of plants, especially in those of parasitic habits, many of which, it is true, are colourless, but others, such as the Santalaceæ, Rhinanthaceæ, and Loranthaceæ, have chlorophyll in abundance; whilst others again, not of parasitic nature, or not known to be so, as many of the Orchids, are colourless. The presence also, of chlorophyll in many of the 'Protozoa,' as *Hydra viridis*, *Bursaria viridis*, &c., is sufficient to indicate the uncertainty of any character thence derived. The circumstance of the plants growing in water, or in the air, has been employed to distinguish the Algæ from the Fungi—it being stated that the former inhabit water, and that the latter flourish only in the air; but that this distinction is untenable is at once obvious, when it is remembered that it often happens that of species even in the same genus, as *Vaucheria*, *Ulothrix*, *Protococcus*, &c., some vegetate in water and others in the air.

The difficulties which attend the separation of the lower *Algæ* and *Fungi* have led several authors, as Kützing, to propose, for some of them, the erection of a group termed *Mycophyceæ*, under which he includes those *Thallophytes* which agree with the rest of the *Fungi* in their vital con-

ditions, and consequent want of colour, and are only distinguished from them by the unessential circumstance of their living in water. But a close investigation of the *genera* included under the above term, will show, beyond any doubt, that nearly all the forms of water-fungi are so closely allied to algan genera, that, with the exception of their wanting colour, scarcely even a generic distinction can be drawn between them, and much less one of family.

Thus the only difference between *Hygrocrocis*, a so-termed water-fungus, and *Leptothrix*, consists in the circumstance that the immotile filaments of the latter contain *phycochrom*, whilst in the other the contents are colourless. But whilst *Leptothrix* is, perhaps, inseparable from some forms of Oscillaria, notwithstanding the motility of the latter, so in the same way do the colourless immotile filaments of the genus *Beggiatoa* come under the class of water-fungi, close to the various forms of *Hygrocrocis*. It has already been remarked by Nägeli that the yeast-fungus corresponds in form and mode of germination with the algan genus *Exococcus*, *Sarcina* is morphologically identical with *Chroococcus*, and that, in its vegetative and reproductive condition, *Achlya* corresponds with *Valonia* or *Bryopsis*.

With respect to the genus *Stereonema*, Kutz., Dr. Cohn proceeds to show that the filamentous growth so named, is not an Alga or Fungus at all, nor in fact any kind of independent organism, but that they are the stems of an infusorium —the *Anthophysa Mülleri*, Bory.

The bunches of apparent spores at the extremities of these filaments are regarded by Dr. Cohn, though apparently not without hesitation, as identical with the *Uvella uva* of Ehrenberg; and, consequently, they are in his view to be looked upon as belonging to the animal kingdom, for he seems, like many other German observers, still to adhere to the exclusively animal nature of many of the Ehrenbergian *Monadina*.

The loss thus inflicted upon the vegetable kingdom by Dr. Cohn, is, however, compensated by the addition to it of part at least of the *Vibrionia*. The animal nature of these minute creatures has, hitherto, never been disputed; but Dr. Cohn sees reason, and affords what appear to be good grounds for it, to believe that several forms of the Vibrionia may be certainly shown to belong to the vegetable kingdom.

The form which seems to have constituted the principal subject of Dr. Cohn's researches in this respect, is that known as *Vibrio lineola*, Ehr., but which was separated from the other Vibriones by Dujardin, under the name of *Bacterium termo*.

The result of his investigations is, that the corpuscles of

Bacterium termo, Duj. (*Vibrio lineola*, Ehr.), represent the developmental condition of a plant; that they are, in fact, the liberated, self-motile cells (swarm-spores) of a *Mycophycean*, closely allied, morphologically, with *Palmella* and *Tetraspora*. He has been unable, however, as yet to discern any motile *cilia* in them. He proposes a new name for this form—*Zooglœa*, with these characters.

Cellulæ minimæ, bacilliformes, hyalinæ, gelatina hyalina in massas mucosas globosas, uvæformes, mox membranaceas consociatæ, dein singulæ elapsæ, per aquam vacillantes.

Syn. Palmella Infusionum, Ehr.; *Micraloa teres*, V. Flotow; *Bacterium termo*, Duj.; *Vibrio lineola*, Ehr.

The general results of his researches on the subject of the *Vibrionia* are thus summed up.

1. The *Vibrionia* all appear to belong to the vegetable kingdom, since they exhibit an immediate, close relationship with manifest *Algæ*.
2. From their want of colour, and their occurrence in putrifying infusions, they belong to the group of *Mycophyceæ*.
3. *Bacterium termo* is the motile swarming form of a genus (*Zooglœa*) closely allied to *Palmella* and *Tetraspora*.
4. *Spirochœte plicatilis* belongs to the genus *Spirulina*.
5. The elongated, motionless *vibriones* (*V. bacillus*, &c.) are allied to the more delicate forms of *Beggiatoa* (Oscillaria).
6. The shorter *Vibriones* and *Spirilli* correspond, in form and in their movement, with the *Oscillariæ* and *Spirulinæ;* but no definite opinion can be given as to their true nature.

The relationship of the Oscillariæ with the Vibrionia was noticed even by the earliest observers. Thus O. F. Müller termed a *Spirulina*, *Vibrio serpens;* nor has the analogy between them been overlooked by Ehrenberg and Perty.

Dr. Cohn goes on to describe the great resemblance between Ehrenberg's *Monas prodigiosa*, the cause of the phenomenon termed "blood in bread," and *Bacterium* or *Zooglœa termo*. The main difference between the two consisting in the shape of the former, which is more spherical or ovoid than bacilliform, and its purple-red colour.* Allied with this are the masses of Vibriones, which, according to Mitscherlich's observation, appear on rotten potatoes, as a kind of ferment, and have the power of *dissolving cellulose* (Monatsb. d. B. Ak., March 1850). All these forms appear to be closely allied to *Zooglœa termo*, if not generically identical with it.

According to Cohn there is not the slightest difference between *Polytoma uvella*, Ehr., and *Chlamydomonas pulvisculus*.

The general summary of his inquiries may be thus stated—That most of the *Mycophyceæ*, agree in family, and even in

* Upon this subject *vide* Fresenius, 'Beiträge zur Mycologie.' Part I.

genus with certain fresh-water Algæ. Whence it follows that that class in general is not a natural group, but an assemblage of plants of various natural families and genera, joined together by a single artificial character.

In this way the Cryptococcaceæ will be arranged under the Palmellaceæ; the Septomiteæ, under the Oscillarieæ and Septotricheæ; the Saprolegnieæ under the Vaucherieæ; some genera would be abolished altogether, such as *Hygrocrocis*, whose species must be regarded as colourless species of *Leptothrix*, and those of *Beggiatoa* as colourless *Oscillariæ*: and as *Spirochæte*, which is identical with *Spirulina plicatilis*; *Vibrio bacillus* would probably be termed *Oscillaria bacillus*, &c.

2. Cohn's observations on the subject of *Chytridium* and some allied genera are of particular interest in several respects, and especially with reference to the important matter of the connexion between parasitic Fungi and certain diseased conditions in plants. The extraordinary prevalence, of late years, of epidemic diseases attacking nearly all cultivated plants, and many of which have been observed to be accompanied with the development of Fungi, renders the determination of the true relations of the one to the other a point of extreme interest and importance, not only in a scientific, but also in an economical sense. To the ancient and well-known pests of 'rust' and 'smut' have been added, it may be said, within a few years, the more destructive potato—and vine—disease; but other important cultivated plants, as the olive—orange—beet-root, as well as timber-trees, belonging to the Coniferous family especially, have also suffered in a similar way.

Disease of this kind has been by no means confined to cultivated plants—these epidemics are not limited to plants useful to mankind—their ravages may be witnessed among the useless and noxious members of the vegetable kingdom, to an almost equal extent with the highly-prized objects of human cultivation.

A remarkable instance of this is afforded in the present Memoir of Cohn. And his observations will go very far to solve any remaining doubts as to the true nature of the relations between the parasite and the disease. Inasmuch as the victim and the destroyer are both plants of the simplest kind—in fact, unicellular algæ, in which the whole process of the invasion and its effects is plainly submitted to the eye. The main question to be determined is, whether the fungus is to be regarded as the cause of the disease, or whether the disease is, as it may be termed, the cause of the fungus. In the former case, the appearance of the Fungus or its spores

would be seen to precede the outbreak of any morbid phenomenon, and in the latter, the reverse would be observable. Other influences of a more general, external, chemical, physical, or it may be, cosmical nature, must, doubtless, concur, to render the disease, however produced — truly epidemic—but these are not now the subject of inquiry.

The decision of the question as above stated is obviously extremely difficult, if not wholly impossible, in the higher plants, owing to the complexity of their structure, and the inability we labour under of tracing microscopically the entire course of the disease, from its first appearance to its termination.

An observation, therefore, which Cohn states, he made in the year 1852, of a disease attacking *unicellular* plants, is of the greatest interest; he observed a sort of epidemy to break out among some Desmideæ which he had kept in a flourishing condition for some time. The consequence was, that the *Closteria*, especially, were nearly all destroyed with great rapidity. He discovered that the cause of this remarkable epidemic was a peculiar microscopic plant, which attached itself to healthy *Closteria*, living at their expense, and consuming or destroying their living contents, and thus killing sthem. The unicellular nature of the victim and of its detroyer allowed the whole proceeding to be observed throughout all its stages; and thus, at any rate, *one* certain fact was established with respect to the significance of epiphytes in epidemic diseases.

The matter is thus described:—"In the beginning of April he observed upon the dead *Closteria* of every species, spherical vesicles of very various dimensions, the smallest being scarcely 1-300‴, and the largest more than 1-50‴ in diameter. These vesicles were filled with opaque, fine-granular but colourless contents. They were seated either singly, or in larger or smaller numbers upon the cell-wall; on some *Closteria* as many as twenty might be counted." The granular contents of the vesicles were seen to become gradually transformed into motile spores or 'swarm-cells,' which escaped through openings or perhaps ruptures of the parent vesicle, and moved about very actively in the water by means of a *single cilium*. When all had escaped, the vesicle was left as a colourless, hyaline membrane.

The spores themselves resembled in shape the minute *monades*, and equally resembled the 'swarm-cells' of *Achlya prolifera*, but from which they differed in their very remarkable motility. From this, and from their correspondence in form and size, Cohn regards it as probable that these *Chytri-*

dium-spores may be identical with *Bodo saltans* of Ehrenberg.

These 'swarm-cells' continued to move about in the water until they reach a situation suited for their further development,—that is to say, until they arrived at a new *Closterium.* And, what was especially remarked, they invariably attacked a *perfectly-healthy*, *briskly-vegetating individual*, in which the green endochrom was in close opposition with the cell-wall. Having attained to its goal, the spore enters into a new stage of development—it *becomes quiescent*, *affixes itself*, and *begins to germinate;* that is to say, the *cilium* disappears, and the spore, surrounded with a rigid membrane, assumes the aspect of a spherical, colourless cell, whose opaque *nucleus* is still distinctly recognizable, in close contact with the membrane of the *Closterium.*

The 'swarm-spore' now rapidly expands into a large vesicle. The *nucleus* undergoes a remarkable change; it disappears, and is replaced by a highly-refractive drop of fluid, probably oil, which at first occupies the greater part of the cell; this drop divides into two, then into several, and ultimately breaks up into numerous granules or droplets. When the vesicle has reached a diameter of about 1-100‴, its contents are seen to be divided into two portions—a *darker* placed on the side at which the vesicle is attached, and a *lighter* at the outer periphery. The former, or dark portion, is produced from the metamorphosis of the *nucleus*, and consists of numerous larger or smaller granules. This darker or granular part of the contents gradually increases at the expense of the other, until at last the whole cell is filled uniformly with it. When this has taken place, the reproduction commences, the granular contents of the vesicle being broken up into a vast number of spores, by which the parent cell is completely filled, as is the case in *Pilobolus* and other Mucorineæ. In most of the fresh-water Algæ, however, the development of spores takes place in the protoplasma lining the wall of the cell.

The parasitic growth thus described, belongs to the genus *Chytridium*, instituted by A. Braun in his Work on 'Rejuvenescence in Nature.'*

The most important point, however, is with respect to the influence exerted by the *Chytridium*, in the course of its development upon the *Closterium.*

When the 'swarm-spore' has reached a certain size, the contents of the Closterium begin to exhibit a morbid change.

* Translated by A. Henfrey, and published by the Ray Society in a volume of Botanical and Physiological Memoirs, p. 185. A collection of great value to the microscopical observer.

The primordial utricle retreats from the wall and contracts, expelling the water from its interior. The peculiarly-arranged Chlorophyll is detached, and begins to be discoloured ; at the same time, the two *vacuoles*, filled with granules at each end of the *Closterium*, disappear ; ultimately, the cell appears colourless and empty, merely some remains of the chlorophyll being left, in the form of an irregular contracted saccular mass or masses in the middle of it. That this morbid change of the cell-contents is due solely and wholly to the influence of the parasite, may be shown beyond all doubt. For the contraction of the primordial sac begins at the spot where the *Chytridium* spore was attached ; and according as the parasite has germinated at the middle of the frond, or at one or other of the ends, it is there that the contents first appear to suffer.

It is clear, therefore, that the *Chytridium* is nourished at the expense of the *Closterium ;* and it may readily be conceived, that a parasite of this kind may produce a most destructive epidemy among the millions of inhabitants in a glass of water, when it is considered that each *Chytridium* may contain 4,000 motile spores, each of which is capable of destroying a *Closterium*, and after a few hours may itself reproduce the same number of spores.

As regards the *mode* in which the fatal influence of the *Chytridium* is exerted, it would seem to consist not simply in an endosmotic action through the walls of the two cells, but by means of a kind of radical fibres which insinuate themselves into the *Closterium*, and which may probably be regarded as equivalent to the *mycelium* of a *fungus*. Dr. A. Braun (l. c.) expressly describes these radical fibres, as they appear to have occurred several times to Cohn's observation, who has given figures of what he saw. It would thence seem, that the Chytridium-vesicle is attached to its organic basis, not simply by adhesion, but by a myceloid tissue, which penetrates the membrane of the *Closterium*, and ramifies in its interior.

The systematic position of this parasitic *fungus*, for such it must obviously be regarded, unless all the Mycophyceæ are merged in the Algan order, is clearly in that order, in the family of the Saprolegnieæ, itself a section of the Vaucherieæ.

With respect to the relations of the 'swarm-cells' of the aquatic *fungi* to the *monades*. Just as the green 'swarm-cells' of the true *algæ* so closely resemble certain astomatous green *infusoria*, that it is impossible in many cases to determine whether a doubtful form belong to the animal or to the vegetable kingdom ; so do the colourless monads in form and colour precisely correspond with the colourless 'swarm-spores' of the *Mycophyceæ*. It is even probable that the number of

motile *cilia* is the same in each group; for whilst all green swarm-spores have at least *two cilia*, the colourless monads and the swarm-cells of *Chytridium* certainly have but *one;** in *Achlya* also, Pringsheim observed but *one*, which accords with Cohn's own observation, though Thuret and De Bary assert positively that they have seen two.

To this it may be added, that a great part of the *Infusoria*, and in fact not merely of the lowest, but also of those standing comparatively high in the scale, enter into a quiescent state, in which they lose all perceptible vestige of movement and organization, and become invested with a rigid, perfectly-closed membrane; apparently in precisely the same way that vegetable swarm-cells, when germinating, secrete a tough cellulose-membrane. And in particular, do the true *monads* present a condition of *encysting*, in which they cannot be distinguished from colourless, quiescent (*fungus*-) cells. Consequently, since neither the 'swarm-cells' of the aquatic *fungi* exhibit any tenable criterion by which they can be distinguished from monads, nor the encysted monads any by which they can be distinguished from the germinating aquatic *fungi*, there is no wonder that, in many cases, it is almost impossible to determine to which category a given organism may belong.

Cohn, however, seems still indisposed to regard all the Ehrenbergian monads as developmental states of *fungi*, as he has convinced himself, he says, of the correctness of Ehrenberg's observation, that many, even very minute species, when kept for some time in coloured water, take up particles of indigo. This circumstance, Cohn regards as sufficient proof of the existence of a mouth, and consequently, of the animal nature of the organism; in neither of which points, however, do we coincide with him.

3. The family of the Volvocina affords so many points of interest and importance, that the study of it may, to a certain extent, be regarded as a fundamental basis for the knowledge of microscopic organisms in general.

The vegetable nature of these organisms, first distinctly recognised by Siebold, and at present admitted by nearly all observers, has already been copiously discussed in the pages of this Journal, and the subject need not here be further adverted to.

The *Volvocina*, in general, may be said to consist of two parts, a colourless hyaline investing cell (Hüllzelle), consisting of cellulose [?], and of green *primordial cells*.† The

* In *Euglena*, however, which is deeply coloured, there is but one *cilium*.

† For the explanation of these terms, *vide* Cohn, *Protococcus pluvialis* ('Botanical and Physiological Memoirs,' published by the Ray Society, 1853).

latter vary in number, from one to any number in the same envelope, being single, for instance, in *Chlamydococcus* (*Protococcus*) and *Chlamydomonas*, eight, as in *Stephanosphæra*, or innumerable, as in *Volvox*. In either case, the *primordial cells* present the character of simple *primordial sacs*, which are not immediately surrounded by any rigid cellulose membrane; consisting merely of a fine-grained protoplasm, coloured red or green by chlorophyll, or a peculiar oil, and often prolonged into mucoid filaments. The primordial cells themselves are produced peripherally into a colourless point, from which arise two vibratile filaments, which penetrate the investing sheath through two openings, and project into the surrounding water. The reproduction is effected by the division of all, or, as in the case of Volvox, of some of the primordial cells, which, in this case, come eventually to resemble the parent organism; or the contents of the germinating primordial cell are more minutely subdivided into motile zoospores of much smaller size (termed *microgonidia*), whose ultimate destination is unknown; the other or larger form are termed *macrogonidia*. The latter, lastly, may assume the 'quiescent' state, each primordial cell within the delicate 'investing membrane' secreting around itself a second, more dense cellulose membrane, which is not perforated by the motile *cilia*, but is in close opposition with the primordial cell, just as in the common plant-cell the cellulose membrane encloses the primordial sac or utricle. In this, manifestly vegetative, *protococcus*-like condition, the cells may remain torpid and without any movement for almost any length of time, until their dormant energies are re-awakened by the addition of water. It would even appear that in many cases, a previous desiccation is required, to render these winter-spores capable of germination. (These winter-spores, in different states in Volvox, have been supposed by Mr. Busk to be represented in the forms termed *V. aureus*, and *V. stellatus*.)

In speaking of *Gonium*, a genus referred by Cohn to the *Volvocina*, he remarks, that his own observations have led him to perceive that its structure is somewhat more complex than it is usually described as being.

In the first place, the entire tablet is surrounded by a perfectly colourless, transparent envelope, presenting the form of a flattened spheroid, the axis of rotation being shorter than the other two. This envelope is not surrounded by any firm or cellulose coat, and appears to be simply gelatinous or mucoid; and it is, consequently, not very readily visible. As in other similar cases, it is best brought into view by the addition of some colouring matter to the water. The green globules are simple or primordial cells—properly of an

octagonal shape, or of a quadrate form with truncated angles; and each of the sixteen cells is enclosed in a colourless, hyaline, delicate, but at the same time rigid membrane. Cohn, however, has hitherto been unable to determine whether this tunic contain cellulose or not. The polygonal *gonium*-cells, thus surrounded by a rigid membrane, are in contact with each other at the angles formed by the transparent, colourless wall, and these conjunctures have been variously understood by different writers. Such as "brides blanches muquenses contractiles," of Turpin, and the "band-formed, tendril-like connecting tubes," of Ehrenberg. In other respects, the gonium-spores resemble the usual 'swarm-spores,' like which, they contain chlorophyll vesicles, starch, &c. They also present a variable number of spaces or vacuoles, filled with water, which are sometimes so numerous as to give the contents a frothy, vesicular aspect. With these variable vacuoles, however, must not be confounded one, two, or three constant, sharply-defined vesicular spaces, situated close to the origin of the vibratile *cilia*. The reproduction is effected in the usual way by the division, several times repeated, of the contents of the cells. Into the particulars of which, resulting as it does in *Gonium* in the production of sixteen cells, Cohn enters at considerable length. He then proceeds to discuss the relation of *Gonium* to other Volvocinæ, and shows, notwithstanding some discrepancies, that it may properly be there placed.

After this, he returns to the subject of the vacuoles in the *Gonium*-cells, and carefully distinguishes the vacuoles, formed apparently by watery secretions in the protoplasma, such as may be observed in all plant-cells, especially when young, from others of a particular kind. In *Gonium*, he observed two or three vacuoles which disappeared and reappeared periodically or rhythmically at short intervals— and which he thence terms contractile vacuoles. He states that these vacuoles are always placed near the point of insertion of the vibratile cilia, and that they contract alternately at regular intervals of so many seconds. Contractile vesicles of precisely-similar kind have been observed in numerous *infusoria*, and were even seen by Ehrenberg long ago, in the zoospores of *Gonium* and of *Volvox*, who entertained the extravagant notion that they were seminal vesicles. Referring to these facts, Dr. Cohn, however, imagines that he was the first to discover the *rhythmical* nature of the contractions of these vacuoles, and enters at very great length, and in great detail, into an account of his observations. Not being aware, we presume, that he was anticipated by more than a year in

this discovery, by Mr. Busk,* who noticed the fact of the existence of rhythmical contractions in the single vacuole in the zoospores of *Volvox globator.* But the most remarkable circumstance connected with this is the apparently precise resemblance of the phenomenon in the two cases. Mr. Busk states, that in *Volvox* the contractions occur very regularly at intervals of 38‴ to 41‴; and Cohn's observations would show that where two vacuoles exist in the same cell, the interval for each vacuole varies between 25‴ and 48‴; and in a case where but one existed, as in Volvox, the intervals, by observation, were 45, 43, 45, 42, 43, 40, 42, 41, 41″. The suddenness of the contraction, and the gradual expansion of the vacuole, are noticed by both observers; in fact, the observations agree in every particular, save only in the circumstance of the situation of the contractile vacuole or vacuoles. Cohn says that he always found them to be situated at the base, as it were, of the cilia—whilst Mr. Busk states that, "it may be situated in any part of the zoospore, or not unfrequently in the base, or even in the midst of one or other of the bands of protoplasm, connecting it with its neighbours."

This rhythmical contraction is, certainly, a remarkable phenomenon in the vegetable kingdom, and worthy of attentive consideration. It does not, as yet, appear to have been observed, except in the above two instances, but will, doubtless, be found to exist in much more numerous cases.

4. The observations on *Hydrodictyon* do not appear to contain more than a very good summary of what is known on that subject, and are illustrated by good figures. We shall return at a future opportunity to this, perhaps, most interesting of all vegetable productions. Upon which will also be found very valuable information in A. Braun's work, above referred to. At the conclusion of this part of his work, Dr. Cohn propounds the following axiom:—That in the lowest forms (fresh-water algæ) a motile, primordial cell, is at the same time the seat of germination (swarm-spore), whilst in the higher cryptogamia, it is the fertilizing organ (swarm-filament); on the other hand, in the latter a quiescent cell (spore) is the seat of germination, whilst in the highest phanerogams, an equivalent cell (pollen-cell) discharges the function of a fertilizing organ.

5. The observations contained in this part of the book relate to the germination of *Zygnema* and *Anabaina.* They are of considerable interest, and will, with the preceding, form the subject of a future notice or abstract.

* Transactions of the Microscopical Society. 'Quarterly Journal of Microscopical Science,' Vol. i., p. 31.

REVIEWS.

Principles of Comparative Physiology. By W. B. Carpenter, M.D., F.R.S. Fourth Edition. London. Churchill.

Although it be an ample apology for the use of the microscope, that he who records a new observation by its aid has added another fact to science, yet we would fain hope that all who use this instrument are more or less impressed with the truth, that by its employment large departments of human knowledge are being moved on. If we wanted an apology for the use of the microscope, we could not do better than point to the works of the learned and laborious President of the Microscopical Society on the various branches of the great science of Biology. Let any one compare the manuals of Physiology that were in use twenty-five years ago with the last editions of Dr. Carpenter's beautiful volumes, and they will see not only how our knowledge of the laws which govern vital phenomena has advanced, but they will see that it has been mainly by the aid of the microscope. They will see too in Dr. Carpenter's volumes how the labours of the humblest observers become in time part and parcel of the great body of special and general facts, which constitute the principles of science. This should be an encouragement to all to persevere in a course of observation, and to record what they have observed. Few perhaps know the whole value and significance of the facts which are presented to their senses ; but if they record them, they become appropriated by those whose special and peculiar gift it is to generalise, and thus to give a form and body to science. Of modern writers and workers few possess this gift to so great an extent as Dr. Carpenter, and he may be justly regarded as the most successful exponent of Physiological science in this country, and one of our most elegant scientific writers. The volume, whose name stands at the head of our article, is intended as a companion to two others, the 'Principles of Human Physiology' and the 'Principles of General Physiology.' The latter work, which is not yet published, together with the present volume, formed the basis of the author's 'Principles of Physiology, General and Comparative,' which will henceforth cease to appear as a single volume.

In the present volume, which is devoted to the department of comparative anatomy and physiology, the author has

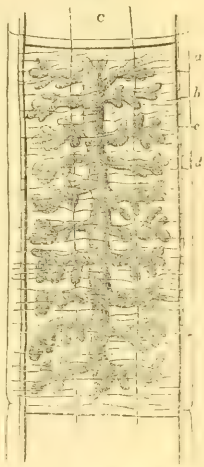
evidently taken the greatest pains to bring it up to the standard of knowledge of the present day. We are glad to find no indications that the author is inclined to rest on his wide-spread reputation and the popularity of his works, but that he has in every department laboured to give the fairest possible exposition of his science. The principal additions and alterations in this volume, as we learn from the author's preface, occur in relation to the water-vascular system of some animals, and the sexuality of Cryptogamic plants. We subjoin Dr. Carpenter's account of the water-vascular system, as its existence and peculiarities have been determined by the aid of the microscope.

It is among the Vermiform members of the articulated series, that we find the 'water-vascular' system acquiring its highest development. But it will be desirable first to study it under the simpler form it presents in the *Rotifera*, which have no rudiment of a sanguiferous system, the chyl-aqueous fluid of the general cavity of the body being the medium alike for conveying nutriment to the solid tissues, and for effecting respiratory changes in them. On either side of the body of these animals, there is usually found a long flexuous tube, which extends from a contractile vesicle (common to both) that opens into the cloaca, towards the anterior region of the body, where it frequently subdivides into branches, one of which may arch over towards the opposite side, and inosculate with a corresponding branch from its tube. Attached to each of these tubes are a number of peculiar organs (usually from two to eight on each side) in which a trembling movement is seen, very like that of a flickering flame; these appear to be pear-shaped sacs, attached by hollow stalks to the main tube, having a long cilium in the interior of each, attached by one extremity to the interior of the sac, and vibrating with a quick undulatory motion in its cavity; and there can be no doubt that their purpose is to keep-up a continual movement in the contents of the aquiferous tubes.—Similar lateral vessels, furnished internally with vibratile cilia, and often ramifying more minutely (especially in the head and anterior part of the body) are found in many of that group of Vermiform animals, clothed over the whole surface of their bodies with cilia, to which the designation *Turbellaria* has of late been given. These vessels have been commonly regarded as *sanguiferous*; and it is certain that the fluid which they contain is sometimes coloured, like the (so-called) blood of Annelida; but it is certain, also, that they have usually, probably always, external orifices, these being sometimes numerous. In *Nais*, instead of actually opening into the cloaca, one set of them comes into close relation to the rectum, the interior of which is richly ciliated; thus reminding us of the parallel distribution of the tracheal system in the larvæ of *Libellulidæ*. In fact, it seems not improbable that the 'water-vascular' system of the lower Articulata (which are all aquatic) is the homologue of the tracheal system of the air-breathing Myriapods and Insects; and that, where it does not convey water directly introduced from without, the fluid which it contains is specially subservient to respiration, establishing a communication between the aerating surface and the tissues of the body generally. There is an almost complete absence among the *Turbellariæ* of any more special respiratory organs. The whole tegumen of the body, being soft and clothed with cilia, is probably subservient to this function; but there are

occasionally to be observed about the head (as in *Nemertes*) particular groups of cilia longer and more closely set than the rest, reminding us of the 'wheels' of the Rotifera.

This 'aquiferous' system of vessels presents its greatest complexity and most elevated character in the group of *Entozoa;* whilst at the same time, there are certain types even of that class, in which it exists under its most simple and least doubtful aspect. It is only, in fact, by tracing it through its principal forms and gradations, that the real import of some parts of this system can be ascertained. In the *Cestoid* worms, we find four principal canals, two on each side (fig. 1, *a b*), running along the body at or near the margins of the segments, and connected together by transverse branches; these anastomose with one another freely in the head, those of the opposite sides being generally connected by an arched canal; whilst at the opposite extremity they all terminate in a single contractile sac opening externally. Besides these trunks (of which the two larger, *a*, have been considered as a double alimentary canal), there is a superficial system of vessels more minutely distributed, which has been regarded as sanguiferous; but these may be traced into connection with the preceding, and their parietes are furnished with vibratile cilia, which keep up a movement of their contents. There is, then, no true sanguiferous system in the Cestoid Worms, any more than there is an alimentary canal; both being replaced by the direct absorption of the nutritious juices from without, in a state ready for assimilation. Yet it is probable that, as in the cases last cited, the 'water-vascular' system contains some other fluid than pure water; and it may even serve, as Professor Van Beneden has suggested, for a urinary apparatus. The fluid contents of these vessels, whatever their nature may be, are kept in motion partly by ciliary action in their interior, and partly by the contractility of their walls; the former method seems to prevail in the smaller trunks, the latter in the large.—In the *Trematode* Worms, we find a regular gradation from what is unquestionably a 'water-vascular,' system homologous with that of the Cestoidea, to an apparatus which nearly approaches the reputed sanguiferous system of the Annelida. One of its most interesting forms is that presented by the *Distoma tereticolle;* in which we find an elongated contractile canal, terminating posteriorly in an external orifice, giving off two contractile trunks, which pass along the two sides of the body without any change of dimension, and unite in an arch above the mouth. The fluid of these vessels is colourless, and contains some minute corpuscles. But besides these, there are a considerable number of smaller trunks, giving-off branches that form a net-work resembling that shown at fig. 2; these trunks, however, have been distinctly found by M. Van Beneden to discharge themselves into the two principal lateral canals, so that they must be considered as forming one system with them, although the fluid which they contain is coloured. This system of vessels, therefore, although usually described as sanguiferous, cannot be properly regarded in that light; and it is obvious, that even when (as happens in the *Echinorhynci*, which are closely allied to the Trematoda) there are no pale, ciliated, non-contractile aquiferous vessels, ter-

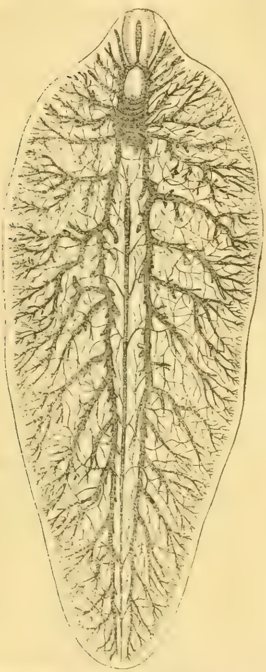
Fig. 1.



Segment of *Tænia Solium*. *a b*, the larger and smaller longitudinal trunks; *c*, ovary; *d*, genital orifice.

minating in an external orifice, but only red, non-ciliated, contractile vessels, which cannot be traced into connection with the exterior, we must abstain from regarding the latter as a true 'sanguiferous' system, since they are obviously but an offset (so to speak) from the 'aquiferous,' specially developed in this particular group of animals.—The nature of the vascular system in the *Nematoid* worms has not yet been made out but there appears strong ground for the belief that in this order also, what has been usually regarded as a sanguiferous system really belongs to the 'aquiferous' type.

Fig. 2.



Anatomy of *Fasciola*[*] *hepaticum* (*Distoma hepaticum*), enlarged, showing the ramifications of the digestive cavity through the whole body of the net-work connected with a median trunk. *a*, the mouth.

An arrangement of a different kind, but one that seems referrible to the 'water-vascular' system of inferior Articulata, is found in the Leech and Earthworm, which, with their allies, constitute the *Monœcious* group of Annelids. In the medicinal *Leech*, there is found on either side of the posterior part of the body a series of seventeen pairs of sacculi, lying between the digestive cæca, and opening by narrow external orifices; although these were long ago considered as respiratory organs, yet they have been of late more generally regarded as organs of secretion, their homological character, however, as a 'water-vascular' system, appears to be demonstrated by the existence of intermediate forms, which connect it with the aquiferous system of Entozoa. Thus in the *Branchiobdella* there are but two pairs of external orifices, one at the anterior and the other at the posterior extremity of the middle third of the body; each of these leads to a trunk, which, after dilating into an ampulla, gives off several tortuous canals, the lining of which is ciliated. In the *Earthworm*, again, there is found in each segment, and on either side of the digestive tube, an enteroid vessel which returns upon itself, and which is lined with cilia; and in other Lumbricidæ, these vessels have cæcal terminations in the general cavity of the body, furnished, like the water-vessels of Rotifera, with long cilia.—Nothing similar to this has been found among the branchiferous Annelida; and it would seem as if the water-vascular system were superseded in them by the apparatus provided for aquatic respiration, which will be hereafter described.—The close resemblance which seems to exist between the multiple sacculi of the Leech, and the air-sacs of the lower Myriapoda, strengthens the reasons already advanced for regarding the 'water-vascular' system as the real homologue of the tracheal system of Myriapods and Insects. And if the suggestion already thrown out, respecting the real nature of the supposed sanguiferous system of Annelida, should prove well-founded, this also would find its parallel in the *closed* tracheal apparatus of certain Insect-larvæ, which is connected, like it, with a branchial apparatus; the difference between the two being that the latter

contains and distributes *air*, whilst the former is filled with an *aeriferous* fluid, which can scarcely be called blood, the distribution of *nutritive* materials being accomplished in both cases by the fluid of the 'general cavity of the body.'

In his account of the sexuality of the Cryptogamia, Dr. Carpenter has embodied the most recent researches on this highly-interesting subject. Every lover of natural history, every student of biology, should be possessed of this new volume by Dr. Carpenter.

THE MICROSCOPE AND ITS APPLICATION TO VEGETABLE ANATOMY AND PHYSIOLOGY. By Dr. HERMANN SCHACHT. Edited by FREDERICK CURREY, M.A. Second Edition. Highley. London.

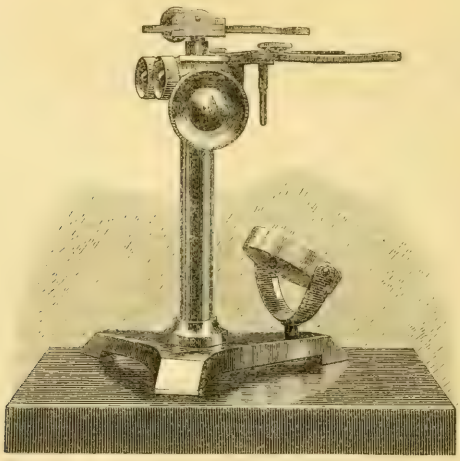
THE fact of this book having reached a second edition justifies the good opinion we have expressed of it on two previous occasions. Mr. Currey has taken the opportunity of adding some new matter, which has very considerably improved this edition. Four chapters have been added at the beginning of the book; the first of which relates to some elementary principles of optics essential to a proper comprehension of the microscope; the second contains a description of different kinds of English microscopes, including as far as is necessary the details of their different parts; the third contains an account of the accessory apparatus and chemical reagents necessary for microscopical investigations in botany; and the fourth relates to the preservation of specimens. Besides these chapters by the editor, Dr. Schacht has furnished a quantity of new matter in manuscript, being the result of his investigations since the last German edition of his work was published in 1852.

The whole of the new matter of this volume will be found interesting to the vegetable microscopist; and we select as examples of the value of the added matter, one extract on instruments and another on microscopic structure.

Dissecting Microscope.—There are many different sorts of dissecting microscopes, which vary according to the fancy of the makers; but as the principle of all must be the same, it will be sufficient to refer to the accompanying fig. 15, which represents one of the best construction by Mr. Ross. The principal points to be attended to in selecting a dissecting microscope are to see that the stage is of sufficient size and strength, and that the arrangements for holding the lenses and moving them in different directions, are convenient. In the instrument in fig. 15, the arm at the top which carries the lens-holder has a forward motion by

rack and pinion, and a traversing motion on a pivot, by which means the lens can be carried in any direction over the stage. The adjustment of the focus is effected by the large milled head at the side. This instrument is usually furnished with lenses of 1 inch, ½ inch, ¼ inch, and 1-10th inch focal lengths, and sometimes with a Wollaston's doublet. The doublet may well be dispensed with, if the observer is possessed of a compound achromatic microscope. In carrying on delicate dissections with this microscope, it is advisable to make use of the arm-rests, which will be described hereafter in the chapter on accessory instruments. Mr. Ross's 1 inch achromatic object-glass may be used in dissecting with this instrument, and will be found most agreeable.

Fig. 15.



Figs. 16, 17, and 18, represent another form of dissecting microscope, called "Quekett's Dissecting Microscope," lately produced by Mr. Highley. Fig. 16 shows the instrument folded up with an Indian-rubber band round it, in a manner which admits of its being carried in the pocket. The two wedge-shaped pieces of wood underneath unfold and form the legs (*see* figs. 17 and 18). Fig. 17 shows the internal arrangement and the manner in which the mirror, lenses, and lens-holder are packed away. The straight, flat bar, on the right in fig. 17, serves to keep the legs from closing together (*see* fig. 18), and also as a support for the mirror, which slides into a piece of brass tubing attached to the flat bar. The circular hole at the lower end of fig. 17 is another piece of brass tubing, into which the lens-holder slides. The instrument is furnished with three lenses, and is to be had at a moderate price.

Fig. 16.

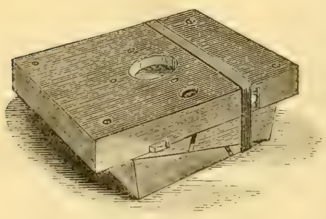


Fig 17.

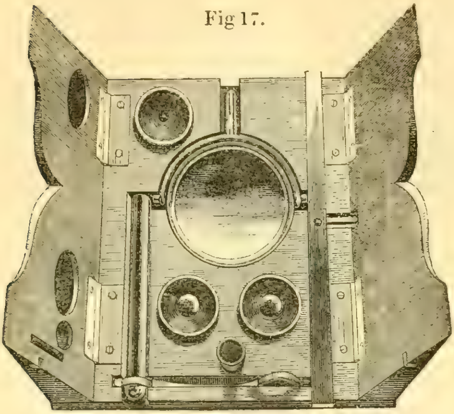
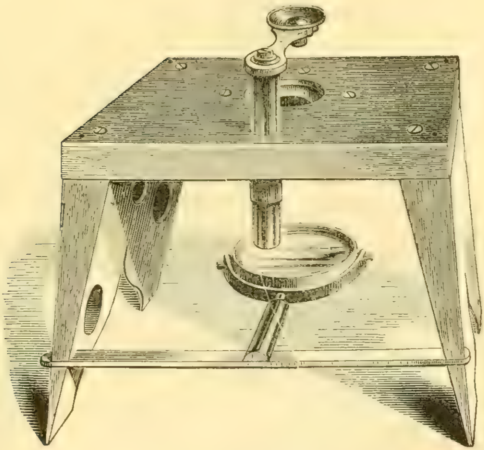


Fig. 18.

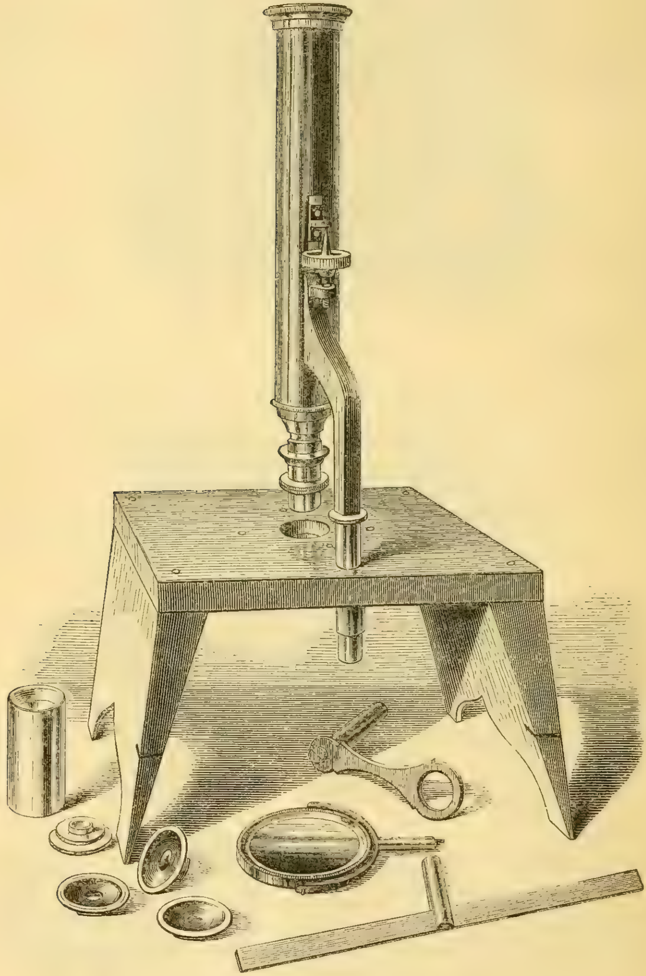


Amongst the new material in this edition are three chapters on the embryogeny of the Coniferæ, taken from Dr. Schacht's recent work, entitled "Beiträge zur Anatomie und Physiologie der Gewächse." From these chapters we extract the following remarks on the pollen of Coniferæ :—

Fig. 109 represents a young pollen-grain of Abies pectinata seen in water, and fig. 110 a somewhat older pollen-grain, also seen in water, where (x) is the place of the thin spot in the cuticle.

Fig. 111 represents a mother-cell of Abies pectinata with four young pollen-grains. At the beginning of May the pollen-grains of Picea vulgaris, if placed in water upon the stage of the microscope, frequently

Fig. 21.



QUEKETT'S TRAVELLING, DISSECTING, AND COMPOUND ACHROMATIC MICROSCOPE.

swell up and escape from the mother-cell; when this takes place, cells called special mother-cells (which exist also in certain other plants, as, for instance, Lavetera) are found to be present.

Fig. 109.

Fig. 110.

Fig. 111.

Figs 112 and 113 represent mother-cells of Picea vulgaris, which have become quadrilolucar by the formation of special mother-cells; the young pollen-grains having been swollen by water have escaped from the mother-cells. These special mother-cells, which were first observed by Nägeli, are nothing more than a primary layer of cellulose secreted by the primordial utricle of the pollen-cell, the pollen-cell itself having originated by division of the primordial utricle. This layer of cellulose, like the mother-cell, is afterwards either absorbed by the pollen-grains themselves, or appropriated in some other way to the perfecting of them. When the four young pollen-cells of Picea escape from their mother-cells, the latter appear, to a certain extent, to be divided by the special mother-cells into four partitions. (*See* fig. 113.) The young pollen-grain is then generally no longer round; the two lateral excrescences, which at a subsequent period characterize the pollen-grain of Picea, Abies, and Larix, are already more or less perceptible.

Fig. 112.

Fig. 113.

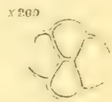


Fig. 114.

Fig. 115.

Fig. 116.

Figs. 114 and 115 represent young pollen-grains at this period, showing the commencement of the formation of the two lateral excrescences. Fig. 116 shows a young pollen-grain of Picea vulgaris, somewhat further developed, seen under water; (x) is the place of egress of the pollen-tube. A laige nucleus, surrounded by granular matter, lies apparently free in the middle of each pollen-grain. From this time the lateral protuberances continue to increase in size, the cuticle, *i. e.* the outer membrane of the pollen-grain, which does not consist of cellulose, becomes stronger and stronger, and delicate markings, streaks, and lines appear upon it, especially upon the protuberances.

Figs. 117 and 118 represent respectively ripe pollen-grains of Abies pectinata and Picea vulgaris which have been soaked for half an hour in oil of lemons; in each figure (a) is the terminal cell of the cellular body; (b) and (c) the pedicel-cells; in both (c) has the appearance of a fissure, as is the case in Larix; (x) is the place of egress for the pollen-tube. The processes going on in the interior of the pollen-grain are at this time concealed, more or less, by the granular contents; nevertheless, I believe that in Abies I have seen the formation of a cell-membrane, that is the origin of a cell, around the central nucleus. When the anther of the above-

mentioned Conifers opens, which takes place about the end of May or the beginning of June, every perfect pollen-grain of Larix Europæa, Abies

Fig. 117.

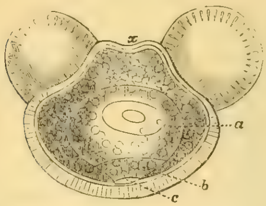
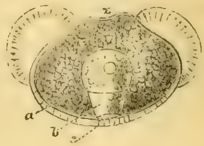


Fig. 118.



pectinata, Picea vulgaris, and Pinus sylvestris, exhibits the cellular body mentioned by Meyer; there may also be seen the fissure between the outer and the inner membrane, *i. e.*, between the pollen-cell and the cuticle; the latter seems to consist of two layers, on which account Meyer speaks of three pollen-membranes. There is also to be seen above this fissure the small pedicel-cell, and over this again a larger cell, which encloses a very manifest large nucleus. Fig. 119 represents a ripe pollen-grain of Larix Europæa seen in water; (*a*) is the terminal cell of the cellular body; (*b*) the larger pedicel-cell; (*c*) and (*d*) the smaller pedicel-cells, having the appearance of fissures in the membrane of the pollen-grain. In Larix the cellular body seems frequently to be composed of four cells instead of three. (*See* figs. 117 and 118.) The above-mentioned cellular body lies opposite to either side of the arcuate space which is found between the two lateral excrescences, and out of which at a later period the pollen-tube emerges. At this place there is to be found in the cuticle of Abies pectinata an attenuated spot, which is rendered manifest in favourable positions of the pollen-grain by the use of sulphuric acid; the same kind of spot probably exists in Picea vulgaris and Pinus sylvestris, and it may be seen also in the cuticle of the Larch, in which plant also the cellular body is situated opposite to this place of egress of the pollen-tube. According to Geleznoff, both the outer membranes, and therefore the cuticle, are completely stripped off. Fig. 120 represents a ripe pollen-grain of Larix Europæa under concentrated sulphuric acid. The contents of it, as well as the true pollen-cell, have disappeared; some oily drops (*y*) are to be seen in the middle of the cuticle (*ct*), which is uninjured, but which has become rose-coloured, and now exhibits two layers; (*x*) is the thin spot in the cuticle intended for the egress of the pollen-tube. The above-mentioned cellular body may be seen most clearly and beautifully in the pollen of the Larch, which is round or nearly so, and in which, as is well known, the two lateral excrescences are wanting; but nevertheless I have derived more information from the study of the pollen-grain of Abies pectinata, Picea vulgaris, and Pinus sylvestris, for which it is necessary to make use of acids and volatile oils.

Fig. 119.

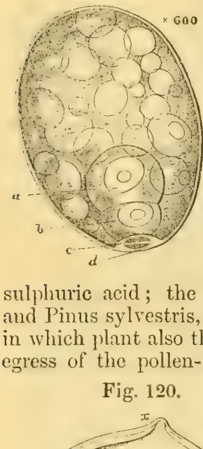
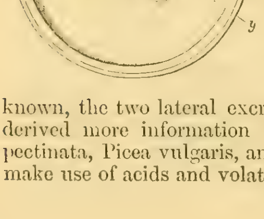


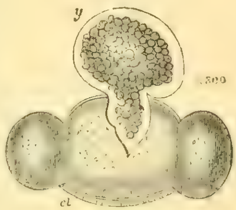
Fig. 120.



By means of the continued action of oil of lemons or oil of turpentine, the contents of the above-mentioned pollen-grains are rendered so transparent that the construction of both the small pedicel-cell, and of the larger terminal cell, as well as their attachment to the wall of the pollen-cell, may be clearly seen. (*See* figs. 117 and 118.) This mode of observation, however, affords no information with regard to the fissure underneath the pedicel-cell. If, however, one or two drops of common sulphuric acid be applied to the pollen when quite fresh, and a thin glass cover be placed over it, the immediate appearance of the pollen-cell may be observed at the spot destined for the egress of the pollen-tube ; it swells and protrudes itself more or less rapidly, and in a more or less perfect condition, through the cuticle, and lies exposed before the eyes of the observer.

Fig. 121 represents a ripe pollen-grain of Picea vulgaris under nitric acid, at the moment when the true pollen-cell (y) emerges at (x): (ct) is the cuticle showing two layers. Fig. 122 represents a similar pollen-grain under concentrated sulphuric acid ; the pollen-cell and its contents have disappeared, leaving only some drops, probably of oil, behind in the cuticle. Figs. 123 and 124 represent the pollen-cell of two ripe pollen-grains forced out of their cuticle by the operation of nitric acid ; (a), (b), and (c) are the cells of the cellular body.

Fig. 121.



The empty cuticle now exhibits its markings still more beautifully. It is now seen that, as well in Abies pectinata as in Picea vulgaris and Pinus sylvestris, the cuticle is very strongly developed at the two excrescences, and still more so between them, opposite to the place of egress of

Fig. 122.

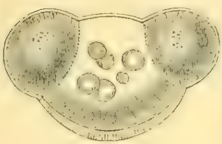


Fig. 123.

Fig. 124.

the pollen-tube, at the point of attachment of the cellular body. At the places where the cuticle is thus strongly developed, two layers may frequently be clearly seen. The fissure between the pollen-cell and the cuticle has now disappeared ; but three cells (and not two only, as in the earlier stages) are always to be seen in the emergent pollen-cell, and these three cells form the cellular body in its interior. (*See* a, b, and c, figs. 118, 123, and 124.) The lowest of these cells (c) is generally the smallest, and becomes united in its growth to the wall of the pollen-cell ; which fact is clearly seen by pushing the covering-glass backwards and forwards : it was this cell which at an earlier period formed the apparent fissure between the cuticle and the pollen-cell. The contiguous cell (b), which is somewhat larger, and which has been hitherto called the pedicel-cell, supports a third cell, viz., the terminal cell of the cellular body (a). I have never seen *more* than three cells in Abies pectinata, Picea vulgaris, and Pinus sylvestris ; but I have never failed to see any one of these three cells in the perfect pollen-grain.

Although I have not been able to trace the development of the cellular

body, it may perhaps be assumed that its three cells originate from the one cell which I have observed in the pollen-grain of Abies pectinata, and probably by repeated divisions of the primordial utricle. The two pedicel-cells, when once formed, do not seem to increase in size, but the terminal-cell grows visibly: in Pinus sylvestris I have met with instances in which the latter cell has completely displaced the granular contents of the pollen-cell, and become distended to such a size as to fill up completely the hollow of the latter. The true pollen-cell appeared about this time to be much decayed, and of a gelatinous consistency; at the apex it was completely absorbed. I cannot, therefore, at present subscribe to Geleznoff's opinion, that the pollen-tube is formed of two membranes.

Fig. 125.

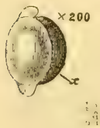


Fig. 126.

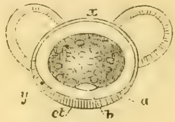


Fig. 127.

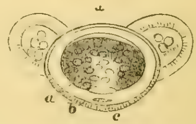


Fig. 125 represents a ripe pollen-grain of Pinus sylvestris viewed dry: at (*x*) the place of egress for the pollen-tube, it is folded together. Figs. 126 and 127 represent similar pollen-grains after long soaking in oil of lemons: (*a*), (*b*), and (*c*), are the cells of the cellular body, which has already displaced the contents of the pollen-cell; the latter is gelatinous and distended; (*x*) is the place of egress for the pollen-tube.

Figs. 128 and 129 represent the pollen-cells of two ripe pollen-grains of Pinus sylvestris forced out of the cuticle by nitric acid; (*a*), (*b*), and (*c*), are the cells of the cellular body; (*y*) is the swollen wall of the pollen-cell.

Fig. 128.

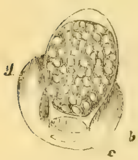
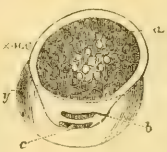


Fig. 129.



I have observed the terminal cell of Pinus sylvestris, which at a latter period makes its appearance as a pollen-tube, to be in some cases filled with granular matter, corresponding chemically to the earlier contents of the pollen-cell; the two pedicel-cells then appeared to be in a dead or dying state. In Picea vulgaris, Abies pectinata, and Larix Europæa, I have not been so fortunate as to be able to trace fully the subsequent development of this terminal cell into the pollen-tube. From the results of prior observations, it seems to me to be not improbable that in other Coniferæ besides the Larch, the cuticle is completely stripped off by the tubular prolongation of the pollen-cell. In the Larch this fact has already been observed by Geleznoff.

In the Autumn of 1853, Encephalartos Altensteini produced two male blossoms at Hamburgh. I examined the pollen whilst fresh, but did not discover the above-mentioned cellular body. The pollen of the Cycadeæ is round, and is, like that of the Coniferæ, furnished with only one place of egress for the pollen-tube. The pollen of Encephalartos, when dry, is folded. In that which I examined, I did not meet with the granular contents which in the Coniferæ are coloured yellow by iodine, and which are made to burst, or become transformed into oil-drops, on the application of sulphuric acid. This pollen seems to me, therefore, to be abnormal, and, consequently, I do not attribute any importance to the circumstance of the non-existence of the cellular body. It remains, therefore, to be ascertained by further examinations of the pollen of the Coniferæ and

Cycadeæ, whether the above-mentioned cellular body in the interior of the pollen is common to all the plants of these families; and whether the terminal cell of this body is intended in all cases to serve the same purposes as in Pinus sylvestris. If it be so, a new and important characteristic of these families will have been obtained. The examination of the pollen should, however, be made only whilst it is fresh; after it has become dry, the *fissure* to which I have referred may still be seen, but not the cellular body. Geleznoff's careful observations on the impregnation of the Larch deserve to be carefully repeated.

If, as may confidently be expected, the appearances which have been here described are found to occur in all the Coniferæ and Cycadeæ, the reproductive organs and the formation of the embryo of these plants will differ from those of all other phanerogams in the three following essential particulars.

1. The Coniferæ and Cycadeæ have naked ovules, that is to say, their ovules originate in an open fruit-scale, whilst in all other (phanerogamous) plants they make their appearance in the interior of a special organ, that is in the hollow of the ovary.

2. The embryo-sac of the Coniferæ and Cycadeæ produces *corpuscula*, which are large cells of the albumen, varying in number, and situated at the apex of the embryo-sac, into which the pollen-tube enters, in order that after having extended itself within the *corpusculum*, it may form the first cells of the embryo. In all other plants the *corpuscula* are wanting, the pollen-tube simply enters into the embryo-sac, and forms therein the first cells of the embryo.

3. The pollen-tube of the Coniferæ and Cycadeæ is not (as is the case in other phanerogams) a prolongation of the inner true pollen-cell, but *an extension of the terminal cell of a small body consisting of several cells*, which body originates in the interior of the pollen-cell, the contents of which it appropriates to the purposes of its own development.

This work is now more than ever one that we can recommend to the botanical student, as an introduction to the use of the microscope.

Lettsomian Lectures on Pulmonary Consumption. By Theophilus Thompson, M.D., F.R.S. London. Highley.

This work consists of three lectures devoted to the subject of pulmonary consumption and its treatment. In the first lecture there are some very good remarks on the microscopic appearances afforded during the progress of tuberculous disease of the lungs. It has oftentimes been denied that the microscope is of any value in the diagnosis of tubercle; and on this subject we subjoin the remarks of Dr. Thompson, whose opinion no one will doubt is that of a thoroughly practical man:—

As respects the progress of consumption, the principal appearances of the expectoration may be described under three divisions:—

1. Frothy; characterising irritation, which, however, may be produced by various causes, besides the presence of tubercular deposit in the cells.

2. Gelatinous. This variety is transparent, resembling a drop of isinglass, not stringy. It is indicative of a chronic form of irritation, unlike that from bronchitis or pneumonia, and is usually tubercular.
3. The purulent, of which there are three marked varieties:—
   (*a*) Simple purulent.
   (*b*) Flocculent; characteristic of secretion from a vomica, modified by absorption of the thinner constituents; very rarely occurring from any other cause.
   (*c*) Non-coherent. This is thick, scanty, rather firmer than common pus; sometimes brought up without cough; often accompanied with slight hæmoptysis. It indicates a chronic form of tubercular affection, in which the diseased action is checked.

Can we, by the aid of the microscope, obtain more definite and positive information regarding these different kinds of expectoration? Microscopical observers have hitherto given us little encouragement in this attempt. Rainey concludes his paper on the minute structure of the lungs with the remark, that the expectoration in the phthisical "most probably is not to be distinguished from that in ordinary bronchitis." He adds, "It will be only during the breaking up of a tubercle that matter truly tuberculous will be expectorated; and this, I believe, can be recognised with certainty by no other character than its containing fragments of the membrane of the air-cells." Dr. William Addison, in an interesting work,* published only five years since, observed—"Great attention used formerly to be paid to the expectoration, with a view to determine whether it was pus and came from a cavity in the lung, or whether it was only mucus from the air-tubes. More recently it has been supposed that a microscopical examination would determine the point. But it is now known that the inquiry is useless, mucus and pus being only varieties of the excretion natural to all mucous or granulation fabrics." Only last year I published a discouraging opinion† as respects the prospect of deriving any practical advantage from this application of the microscope. Since that time, however, I have been induced to change that opinion, and I now hope to show that, with careful attention, the microscope will afford definite and conclusive information regarding the disease in its progress, and open views of peculiar interest respecting its origin.

Frothy expectoration contains stringy mucus and the outer layer of epithelium, cilia being often observable. A gentleman whom I visited a few weeks since with Dr. Crosse was affected with obstinate cough. There was some hereditary tendency to consumption; his aspect was rather unpromising, and there was dull percussion in the right subscapular region. It was doubtful whether this dull percussion depended on tubercular consolidation; but the absence of any tubercular element in the purely bronchial frothy sputum, when microscopically examined, encouraged us to give a favourable prognosis, which has happily been confirmed by the successful issue of the case.

The second variety—namely, the gelatinous, is transparent, not stringy, and resists pressure between the glasses of the microscope. It contains granules, molecules, not aggregated, cells partly devoid of granules, and oil globules. (See fig. 3.)

A more advanced stage is seen in fig. 4.

Of the third kind—namely, the purulent—the flocculent is so characteristic of phthisis, that from its external appearances alone we may almost

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* On Healthy and Diseased Structure, p. 159.
† Clinical Lectures on Pulmonary Consumption, p. 49.

venture on a diagnosis. Under the microscope the correctness of this opinion is usually established by the appearance, mixed with pus corpus-

Fig. 3.

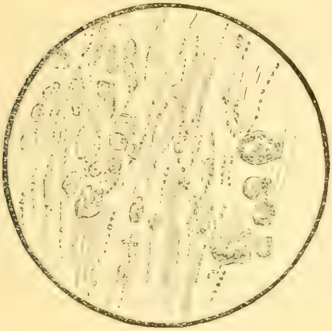
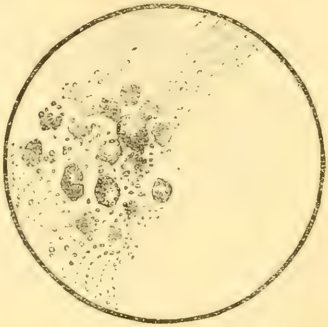


Fig. 4.



cles, of the unmistakable shrivelled cells, granules, molecules, and oil globules (see fig. 5), not unfrequently also of the curled elastic tissue surrounding the pulmonary vesicles.

Fig. 5.

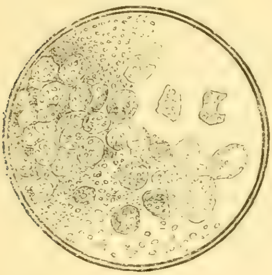
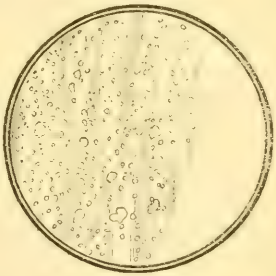


Fig. 6.*



Every one must feel, after reading this passage, that however imperfect the assistance yet obtained by the practical physician from the use of the microscope, that in the course of a short time it will form one of his important means of diagnosis.

* Fig. 6 represents the same after the application of acetic acid.

NOTES AND CORRESPONDENCE.

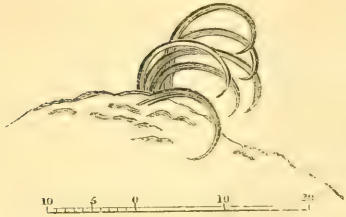
Feet and Wings of Insects.—In confirmation of the opinion of Mr. Hepworth and other naturalists, that the use of the cushions beset with hairs terminating in glands secreting a glutinous substance, is to attach the foot to what it walks on by means of such secretion, and *not* by suction, I would suggest that the *hooks* on the feet of flies are intended not to attach the fly to anything, but to be used as fulcrums (fulcra, Mr. Editor, " if you think it better English," as Lord Plunket said when corrected for using the word memorandums), or props which the fly can push against when it wishes to detach the cushions. Without these hook-shaped props, the fly, when once stuck fast, must remain so.

Some Hymenoptera, Messrs. Kirby and Spence state, have hooklets on their wings. These are used to attach one wing to the adjoining wing during the insect's flight. My observation leads me to think that these hooks are a distinguishing characteristic of all Hymenoptera ; but I throw out the suggestion for the investigation of naturalists. The hooks vary very much in number. In some minute Hymenoptera, we find but three, while on the wasp I think there are twenty-four, and on the hornet, twenty-eight. They are invariably on the smaller wing, and the margin of the other is folded back, and thickened at the edge to give the hooks a firm hold of it.

So far as my experience goes, these hooks are confined to the Hymenoptera, with but one exception—the aphis. Every aphis possesses one or more hooks on the smaller wing for the same purpose of attachment ; but while in the Hymenoptera, they are arranged separately along the margin of the wing, in the aphis, on the other hand, the hooks, however numerous, spring from one point, or at least are placed as closely as possible together. The number of hooks differs, in the different varieties of aphis that I have examined, from one to seven.

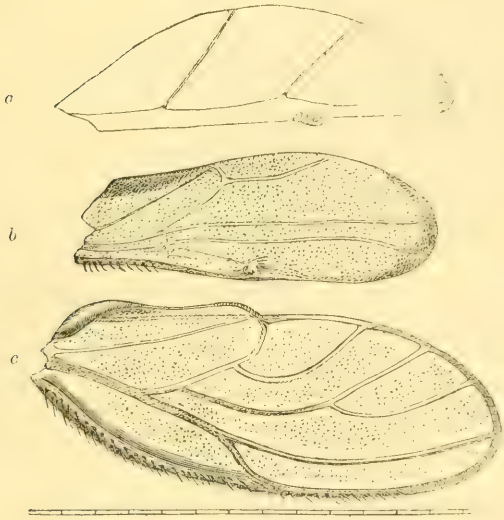
An aphis found on the Box and on the Hawthorn appeared at first to have none, but after a careful inspection, the hook was found of a different shape from what is usual, inserted in the wing not quite at the edge, and standing out perpendicular to the plane of the wing. The Box- and the Hawthorn-aphis have this further peculiarity, that to compensate for the absence of hooks in their usual position, they have a row of hooks near the insertion of the wing in the insect's body, and the larger wing has a corresponding fold at the same place to receive them.—JOHN TYRRELL, *Newcourt.*

Fig. 1.



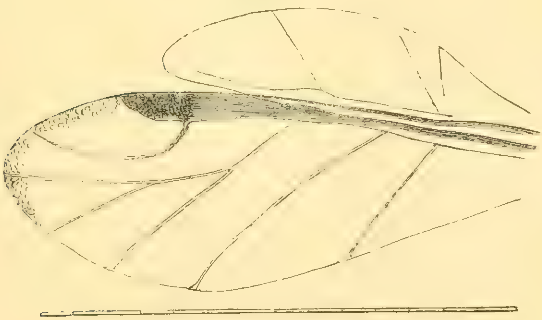
Hooks on the Sycamore-aphis, magnified about 800 diameters.

Fig. 2.



a, Wing of Sycamore-aphis; *b*, *c*, Wings of Box-aphis.

Fig. 3.



Wings of Sycamore-aphis, held together by the hooks.

The Markings of the Pleurosigma, &c.—In the 'Memoranda' of the last number of your interesting Journal, a short notice was inserted on the "curious effect of moisture on the markings of the *Pleurosigma*," in which I spoke of the subject of the markings as one, "still, I presume, involved in obscurity." When this was written, I had not seen the following quotation from the 'Philosophical Magazine' for January, 1855, which occurs in an abstract of a paper read before the Royal Society, "On the Structure of certain Microscopic Test-objects, and their Action on the Transmitted Rays of Light." By Charles Brooke, M.A., F.R.S. The passage is as follows: "The 'dots' have by some been supposed to be depressions; this however is clearly not the case, as fracture is invariably observed to take place *between* the rows of dots, and not *through* them, as would naturally occur if the dots were depressions, and consequently the substance thinner there than elsewhere." Now when writing the former notice, and quoting a passage from the introduction to the 'Micrographic Dictionary' now publishing, in which a diametrically-opposite view is maintained, I was not prepared to find such eminent observers as the authors of the above-mentioned work, and Mr. Brooke, taking such *wholly* irreconcilable views, and each, moreover, basing his view upon *wholly* irreconcilable statements of the same fact, namely, the course of the line of fracture of the shell. The observation of this fact is, I should think, simple and easy to an experienced observer who possesses our most powerful objectives, and I am not without hope that the juxtaposition of two such contradictory statements made by such experienced observers, will induce some one qualified by experience, and possessed of sufficient instrumental means, to bring forward such undeniable evidence of the truth of either one statement or the other, as may set at rest the question of the course of the line of fracture; which will be a step, and an important step, towards ascertaining the precise nature of the markings. I may add, that in those species of the genus *Pleurosigma*, which have the "striæ transverse and longitudinal," such as the *P. Hippocampus*, I have observed that when moisture has insinuated itself between the glasses in which they are mounted, the boundary line between dryness and moisture has always a tendency to arrange itself in lines, either transversely across or along the shell, which in this case are manifestly parallel to the two directions of least distance of the dots. Granting that the Diatomaceæ belong to the Vegetable Kingdom, the nature of these dots, may, I think, be added to the list of *questiones vexatæ* in vegetable anatomy adduced by Mr. F. Currey, in his paper in the ninth number of this Journal, "On the Spiral Threads of the Genus Trichia,"

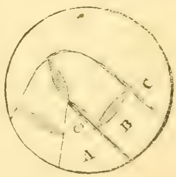
in which he says, "the opinions of observers not only differ from one another, but are so utterly and diametrically at variance, that if one side be right, the other must be altogether wrong."—G. Hunt, *Handsworth*, *Birmingham*.

Definition of Delicate Test Objects.—With Powell and Lealand's 1-4th objective, and the A eye-piece, the magnifying power being 200 diameters, using also their improved achromatic condenser, No. 8 aperture, without the stop for the central rays, I have clearly defined the double set of lines at the same time of *Navicula cuspidata* and *Pleurosigma Fasciola*, also the fine markings of *Navicula obscura* and *P. delicatula*, and the still more difficult ones of *Nitzschia sigmoidea*.

With the 1-8th objective and the same eye-piece, the magnifying power being 400 diameters, I have brought out the dots of *Pleurosigma obscura* and *P. delicatula* as plain as in the *P. angulata*, and also the very delicate markings of the Amician test, *Grammatophora subtilissima*, and *Navicula rhomboides* and (*Pleurosigma?*) *macrum*. In fact the Diatomaceæ generally are brought out in a most distinct manner.

The angular aperture of the 1-4th objective is 95°, of the 1-8th, 125°, and of the condenser, 105°.

The microscope is placed at the polarizing angle 56° 45′. The illumination is that of the small camphine lamp, the base of the flame being $7\frac{3}{4}$ inches from the level of the table, the flat side of the mirror being uppermost, and nearly horizontal, and $2\frac{1}{2}$ inches below the base of the flame, and at a distance from it of about $1\frac{3}{4}$ inches. The achromatic condenser is racked up very near to the object: with this preliminary arrangement, by a slight movement of the mirror and condenser, a small triangle of brilliant light is obtained at the base of the field; above the bright light is a deep yellow, filling the space of more than half the remainder of the field, the remaining portion at the top being very dark; on the yellow portion of the field the object is so arranged, that the intense light from the bright angle may be thrown upon it, and then the delicate markings immediately appear. This diagram may explain it more clearly.



A, the angle of bright light. B, yellow ground. C, dark ground.

The objects are placed in either position as placed in the diagram.

The markings of (*Pleurosigma?*) *macrum*, *N. rhomboides*, the Amician test, and *Grammatophora*, are made still more distinct by placing stop 1 as marked in the portion A of the diagram. —E. L.

Cheap Microscopes.—The President of the Microscopical Society in his late address drew attention to the general impression, that in order to make good observations it was necessary to have a high-priced microscope. He denied this, and stated his conviction that all the arrangements necessary for accurate investigation might be obtained at a very much lower price, than is given for the very perfect and beautiful apparatus of our first makers. The drawback on purchasing cheap microscopes is the want of knowledge of the properties of good glasses on the part of beginners. As the use of the microscope is now becoming a matter of educational importance, and as in order that it may be used by all, it must be sold at a price to be attained by all and at the same time a good instrument insured, the Society of Arts has offered two prizes for the best microscopes at stated prices. We have much pleasure in drawing attention to the following announcement of this Society. The Council has determined to offer special prizes—

1. For a *School Microscope*, to be sold to the public at a price not exceeding 10*s.* 6*d.*—Prize—*The Society's Medal.*

To be a simple microscope, furnished with powers as low as those of a pocket-magnifier, for the purpose of observing flowers, insects, &c., without dissection. The lenses should range from two inches to 1-8th of an inch; the focal adjustment to be by rack-work, extending sufficiently above the stage to allow a thick object to be brought under the lowest power. It should be furnished with plyers, a concave mirror, and an illuminating lens, also a live box, or, instead of it, two or three glass cells of different depths, a few slips of common glass, and a few pieces of thin glass for covers.

Makers are requested to state at what additional price they will undertake to supply a doublet of 1-16th or 1-20th of an inch, applicable to any instrument as above described.

2. For a *Teacher's* or *Student's Microscope*, to be sold to the public at a price not exceeding 3*l.* 3*s.*—Prize—*The Society's Medal.*

To be a compound Achromatic Microscope, with two eye-pieces and two object-glasses, one magnifying 120 diameters with the lower eye-piece, the other magnifying 25 diameters with the lower eye-piece. It should be furnished with a diaphragm, having various-sized openings, mirror, side illuminator, live box, forceps stage and case.

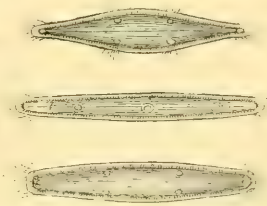
In the event of the medal being awarded, the Council is prepared to take 100 of the smaller and 50 of the larger microscopes, at the trade discount.

The instruments for which the medals shall have been awarded will be retained by the Society as standards; and the successful competitors must enter into a guarantee to supply their microscopes at the foregoing prices, and of equal quality with those retained, and to change them if not found satisfactory.

The Council, in all cases, expressly reserves the power of withholding the premium or medal altogether, should the essays and articles sent in competition not be considered worthy of reward.

The essays and articles intended for competition must be delivered, addressed to the Secretary, at the Society's house, free of expense, on or before the 1st of May, 1855.

Cilia in Diatomaceæ.—During my examinations, near the end of the last summer, of the ciliary motion in the Desmidieæ, I frequently noticed in many of the more commonly met with forms of the Diatomaceæ a similar arrangement of cilia. I have attentively watched Diatomaceæ moving slowly and steadily across the field of the microscope, when upon meeting with any obstacle to their progress they have changed their course, or pushed the obstruction aside, as if conscious of an impediment. I have repeatedly satisfied myself that their motive power is derived from cilia, arranged around openings at either end; in some around central openings, which with those cilia at the ends act as paddles or propellers. This arrangement is indicated merely in the very rough sketch I made at the time, as I then anticipated other opportunities for the purpose of rendering them more perfect. Before I had made out the cilia, I thought it very remarkable to see these little bodies moving along, and steering their course by a power which they were evidently able to call into action and restrain at will, I was therefore agreeably surprised to find this motive power due to cilia. The position assigned to the cilia, it will be observed, differs much from the ciliary processes found in the Desmidieæ, and which is only, I believe, a physical force acting independently of any *controlling power;* on the contrary, with the Diatomaceæ their cilia appear to act in obedience to some will, for intervals of rest and motion are most clearly to be distinguished; and this knowledge would naturally induce a doubt, or cause one to inquire once



more, whether the Diatomaceæ are properly classed in the vegetable kingdom?

I would take this opportunity of impressing upon the attention of those microscopists, who wish to examine for themselves the ciliary movements of the lower forms of life, the necessity of using only very shallow cells for the purpose, say of from 1-50th to 1-100th of an inch deep, and glass covers of from 1-150th to 1-250th of an inch thick. The objective must be 1-4th or 1-8th, with a good eye-piece; the objects themselves should be carefully illuminated, by using for the purpose a parabolic reflector, or a Gillett's condenser, and the examination be conducted during very bright weather or in sunlight.—J. HOGG.

New Mode of Illumination.—Your obliging insertion in the last number of the 'Microscopical Journal,' of my note on 'Closterium,'* tempts me to send you another Memorandum, in the hope it may be found worthy of a similar corner in your next.

Those who, like myself, do not happen to possess either a Wenham's or Shadbolt's parabolic condenser, will find the following plan an efficient substitute, perhaps even superior to those instruments for defining certain structures.

With a steady clear lamp-light throw a strong background illumination, according to the method of the Rev. Mr. Reade, rendered more intense by using a bull's-eye lens placed near, and with its convexity toward the light, and a smaller condensing lens (on a separate stand), focusing the bright light on the object beneath the stage, and at an angle beyond the range of the angular aperture of the objective. Then let the rays which have passed through the slide be received above the stage, on either a side-reflector or a Lieberkuhn, placed so as to reflect them on the object from the side opposite to the light. A brilliant illumination on a dark or black ground is thus produced, which displays many objects with extreme distinctness and beauty, and, as in all background illumination, with the great advantage of preserving their natural form and colour.

Among those best adapted for illustration by this method, are the coloured spiculæ of *Gorgonia;* recent and fossil *Foraminifera;* partially-transparent injected preparations; palate of *Myliobates;* hair of Indian Bat; scales of *Lepisma*, of *Amathusia Horsfeldii*, and of many other butterflies and

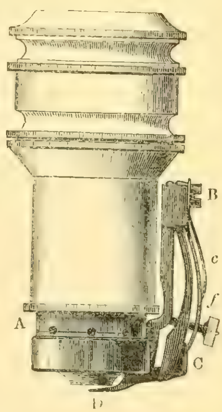
* Allow me to correct a mistake of your printer, in inserting the last paragraph but two at page 172, which was not intended for the press, but to account for the erasure of some experiments narrated in the original MS.

moths, all of which may be beautifully seen under an ordinary 1-inch lens. With a $\frac{1}{2}$-inch of moderate aperture (57°), and Lieberkuhn, the markings on several Diatomaceæ, as *N. formosa*, *elongata*, *Hippocampus*, *Baltica*, and *Stauroneis Phœnicenteron* are splendidly shown in distinct *ridges;* and by using the draw-tube, a clear definition may be obtained of *P. angulatum.* I have, even with the same lens, exhibited palpable indications of the lines on an (American) Amician test, *P. gracilis.*—T. G. Wright, M.D., *Wakefield.*

Another Finder.—The best description of "Finder" for the microscopist appears still to be an open question.

It has been made abundantly evident that a strong predilection exists in favour of the ring, or circle around the object, although the methods of effecting it have hitherto been most uncertain in their results, as well as both difficult to accomplish, and disfiguring in appearance to the slide when required for the cabinet. To produce this ring by "machinery" had occupied my attention long before Mr. Tyrrell's description of a "Finder" appeared in your third number, but, on reading that, a new idea was suggested by the *rectangular* scale. The result has been the cross lines near the edge of the slide, as shown in the accompanying diagram; but as it was soon made apparent that, in addition to these, some definite indication of the precise spot was absolutely necessary, the original idea was fallen back upon, and has been put into practice with the most perfect success.

The annexed sketch is the full size of the original, attached to a "quarter" of Ross.



A, a brass cap, fitting upon the end of the object-glass, which it entirely covers up and protects from injury. The upper end is thin and slit so as to move round easily without shaking.

B, a stem soldered to the side of the cap, with the upper end having two projecting sides to steady the ends of C, *e*, and *f*, which are firmly screwed to it.

C, an elastic arm of hammered brass, which carries at its lower end, D, a lever of thin brass plate, having a fragment of diamond inserted in its thinner end, and directly under the centre of the cap A.

c and *f* are two springs, pressing upon the shorter end of

the lever D, the longer one, *f*, has a hole, to allow the screw, *h*, to pass without touching it.

g, a screw, holding the two springs and the elastic arm to the arm of the cap.

h, a milled screw, to adjust the elastic arm C, so as to bring the diamond point away from the centre, according to the size of the ring required.

I have one attached to a half-inch, but the quarter is by far the most useful, as this is the power I generally employ in searching any new material.

Before commencing the examination of a slide, the latter should be firmly fixed to the stage, by bringing the slip to press tightly on its edge. Having now found any particular specimen and brought it into the centre of the field, and having been careful to adjust the mirror in a line with the tube, if not using a condenser, the body of the instrument may be run up and the cap A slipped on to the end of the object-glass, with the upright arm, B, either directly in front, or behind, in a line with the stem. The whole may then be moved down again till the scratching-point touches the surface of the cover, which can easily be seen by the movement of the lever when looking at it horizontally, and applying the finger to the side of the screw *h*, the cap may be turned round on its centre, making a neatly-turned circular scratch on the cover, with the object perfectly central. By working the slide upwards or downwards, and making a straight line at the side, either up to the edge itself, or crossing a longer line parallel with the edge, and produced by using the other movement of the stage, any particular circle may always be found at once, and may also be registered on the end of the slide. After the circle has been completed, the vertical motion of the stage will produce a *line with a loop at the end*, which is, perhaps, the most ready guide to the object sought for.

After a number of trials and various alterations, the present arrangement is the simplest and most effective I have been able to devise; but being only an amateur workman, it does not contain so many "perfections," perhaps, as any of our celebrated opticians may be able to add to it should it become an article of "manufacture;" as, for instance, a wheel and pinion to give the circular motion, and again, by a graduated scale on the lever D, the size of the circle, which ranges up to an eighth of an inch, might be determined beforehand with the greatest nicety. Slides thus marked are by no means conspicuous, and require to be seen by reflected light to detect the rings. Their appearance may be judged of by the

accompanying duplicates, one of which being mounted dry, that is, with the cover merely supported by its edge, will show the delicacy and little risk there is in cracking the thin glass. In examining a slide, it will, of course, be necessary to focus for the upper surface of the cover first, until the circle be found, when, on lowering the object-glass, the specimen will be seen in the field, if the light in both cases has been central.—W. K. Bridgman, *Norwich.*

On the Aperture of Object-glasses.—Having read over the remarks in your last number on the Aperture of Object-glasses, by my friend Mr. Wenham and Dr. Robinson, I should wish to offer a few remarks; not that I shall attempt to take up the valuable pages of your Journal by discussing the matter in the two papers, but I should wish to call attention to a particular fact connected with a well-conducted experiment named in my last communication, and which neither Mr. Wenham nor Dr. Robinson have noticed. For if it be a fact *in one case* that the angle of aperture of an object-glass be reduced when brought to bear on an object mounted in balsam, it must be so *in every case.* The experiment which I refer to is one which I have again tried with great caution, and with the same result.

Let *a a* be a pencil of light falling upon the under-surface of the anterior lens of a set of wide aperture, say 152°, and let the central ray of the pencil *a a* make an angle of about 75° with the axis of the lens *b b;* take two sliders, the one containing an object mounted dry, and the other an object mounted in balsam, and let them be so selected that the object in both sliders may be exactly in focus when placed under the objective, without having occasion to move the adjusting screw. Now, when the pencil of light makes an angle so great as above stated, a part of the field of view will not be perfectly illuminated; place the slide with the dry object under the objective, and it will be found that the field is still partly illuminated as before; then remove this slide and place the one below containing the object mounted in balsam, the field is still invariably illuminated in the same manner, there being no difference in the illumination, however the rays may have

been refracted before they reach the objective, either by the glass in the first slide or by the glass and balsam combined in the second: it being thus proved that however the rays may have been refracted by the different media, and however we may reason from theory upon those refractions, the actual working aperture of the objective remains, under all conditions, exactly the same; for if it were reduced by any of those refractions, not one single ray of the pencil *a a* could ever reach the eye of the observer at the upper part of the microscope. Indeed, I have tried this experiment with a set of lenses of 1-12th of an inch focus and 152° of aperture, and on removing those from the instrument, and placing on it another set of the same power, but of 148° of aperture, the field was unilluminated, and the effect of the black ground immediately produced, at once pointing out that if by any refraction the aperture of the lens had been reduced only 2° on each side of the perpendicular, the effect of each refraction would have been immediately seen. With respect to the markings on the Diatomaceæ, and the manner in which they are effected by balsam, I think Dr. Robinson has forgotten that none of those minute and beautiful forms are without some portion of colour; and although balsam makes objects more transparent, and consequently appears to rob them of a part of their colour, it still leaves sufficient even in the smaller forms of the Diatomaceæ to render both them and their markings perfectly visible. Who would ever contend that the markings on the larger *Pinnularia* are not much better seen in balsam than when the object is mounted dry? and, as I stated in my last communication, I have two slides of the *N. rhomboides* (Amician test), the one mounted dry and the other in balsam, and I can at all times see the delicate markings on this object quite as well, or even better, on the specimens in balsam than on those which are mounted dry. To an uneducated eye the markings on the dry objects may appear more striking, on account of their stronger colour; but to a well-educated eye the superior sharpness and exquisite beauty of those objects when balsam-mounted is such as it would be vain to look for when they are in their natural state. Again, I think it rather an unfair way of testing the visibility of the markings, either in or out of balsam, by the use of high eye-pieces; for at the same time that you reduce the light by the eye-piece, you destroy the effect of the difference of colour, and therefore, of course, when this difference is small, as it is in balsam-mounted Diatomaceæ, you might as well blot out the object altogether. To see objects well when they are so very transparent, you want all the light you can obtain, as the greater the light the

greater will be any dissimilarity in colour of the various parts; but if you destroy the intensity of the light, by using a high power eye-piece, you might as well try to see it with the low power, and a telescopic sun-shade over it. I have a five-feet achromatic telescope which will show the fifth star in the trapezium of Orion very well with a power of 100; but with higher powers you cannot see the small star, because the telescope has not sufficient light to show the difference in the colour of the faint star and the nebula by which it is surrounded. This equally applies to microscopic vision, particularly where the object is very transparent, and the difference in colour between the object and the balsam comparatively small.

With regard to the diminished aperture, as made apparent by the methods employed by Mr. Wenham and Dr. Robinson, when applied to balsam-mounted objects, I think it is very easy to account for the conclusions they have been led to; for every one conversant with optical instruments knows that the larger the aperture in proportion to the focus, the greater will be the aberration of the rays passing through or from the edge of such aperture, as, in a telescope of large aperture, one angular inch in the centre will give as much light as eight or ten angular inches taken in the form of a ring round the extreme edge of the glass; no wonder then, that in the objective of a microscope, where the diameter of the aperture is seven and a half times that of the focus (which it is when the aperture is 152°), the aberrations from near the edges of the glass should be so great as to cause the rays not to be visible after having passed through balsam.

I recollect that the last time I had the pleasure of seeing Mr. Wenham he told me he had made a 1-8th, the aperture of which was somewhere between 170° and 180°, but on account of the weakness of the rays at the edges, arising from aberration, he would not undertake to say within 4° or 5° what the exact aperture really was.

With these observations I shall conclude my remarks, being fully persuaded that when objects are mounted in balsam that medium has no effect in reducing the aperture of the objective, and that no external cause, except a fluid or other medium in actual contact with the objective, can, consistently with the known laws of optics, produce such an effect.—J. D. SOLLITT, *Hull.*

On Washing and Concentrating Diatomaceæ.—Having read in your last Journal the excellent paper by Mr. Okeden "On a mode of Washing and Concentrating Diatomaceous Earths,"

and having lately used a similar process with some success, by allowing the Diatoms to fall through a given length of water, I beg to forward you the method I have adopted.

I first boil the deposit in strong hydrochloric acid for five or ten minutes, then allow it to subside, pour off all the acid, and by a few washings get as much of it away as possible. Then treat the deposit in the same way with strong nitric acid, washing the deposit by repeated washings to get rid of the remaining acid. When this is done, I then separate the Diatoms according to their different gravities by allowing them to pass through a column of water in the following manner:—

I take a long glass tube about four feet long and half an inch in bore. At the bottom of this tube is fixed a stop-cock to enable me to let out any of the Diatoms during any stage of the process. Having nearly filled this tube with distilled water, I pour in my deposit washed free from the acids. I watch the deposit as it falls slowly and gradually down the tube, and with a Codington lens can easily detect the larger Diatoms as they are precipitated. In about a quarter of an hour, many of the larger forms will have descended to the bottom of the tube. By turning the tap at the bottom of the tube, I let out a drop of the mixture on a slide, and examine it with a low power ($\frac{1}{2}$-inch); and if it be tolerably clear, and the Diatoms of one character, I then let off five or six inches of the mixture into a test-tube, and set it aside for re-examination after the Diatoms have subsided. In a quarter of an hour more, I again let off into another test-tube six or eight inches more of the mixture, and place it aside to settle. In half an hour more I let off into another test-tube six or eight inches of the mixture, which will contain the finer Diatoms by themselves, generally free from all mud and sand. I then pass each of these washings again through the long tube of distilled water; and by examining the mixture during the process of its subsidence, I am enabled to let out the heavier particles of sand or mud, and to obtain pretty clean all those Diatoms which are alike in size, or at all events in specific gravity. Some Diatoms take a longer time than others in settling to the bottom of the tube, and separating themselves from extraneous matter, such as the *Nitzschia closterium*, &c.; but, by a little patience, and an extra washing through the tube, these difficulties may, in a great measure, be overcome. By this method, I have found the *Pleurosigmata*, *Pinnulariæ*, *Surirellæ*, and *Synedræ*, very well separated, those of a like character being found together. I have been stimulated to send you these few remarks on the washing of

Diatomaceæ, on account of the great difficulty I have hitherto experienced in procuring slides free from mud, sand, and other extraneous matters.—H. Munro, M.D., M.R.C.S., &c., *Hull.*

Campylodiscus clypeus.—On September 6, I found in brackish water, near Yarmouth, what I took to be *Campylodiscus bicostatus*, specimens of which so named I distributed amongst several members of the British Association, at the Liverpool meeting. I now find it should have been named *C. clypeus*, and which I understand is new to Britain.—R. Wigham, *Norwich.*

Cilia on the surface of Confervæ.—Although I am aware that the existence of cilia on the *Oscillatoriæ* has been inferred from the motion of particles of matter in the water in their neighbourhood, I am not certain whether any observer has distinctly *seen them.* It may be of interest to some of your readers to know that by using a dark stop with the achromatic condenser, the whole surface of a large species of *Oscillatoria* (found in brackish water) may be seen covered with cilia moving in a circular sweeping wave round the axis of the organism: this motion is particularly distinct and beautiful at the *sutures* of the segments, where the cilia may be seen *en profile*, and seem to form a distinct fringe. At the "smaller end," which one occasionally finds on the longer pieces, the motion is very lively, as well as that peculiar "vermicular" waving which is so characteristic of the species. The ciliary movements are only to be made out clearly (in the specimens which I have examined) whilst they are in a state of *progression*, which inclines me to suppose that *that* motion at least is produced by their agency.

The object-glass used was a 1-4th, of Mr. Pillischer's make, with a large angle of aperture, and the shallow eye-piece.—G. H. Kingsley, M.D., *Glossop Hall, Derbyshire.*

On an easy method of wiping Thin Glass Covers.—As many of the readers of the 'Microscopical Journal,' like myself, may have found great difficulty in wiping the thin glass covers for microscopic objects, by the ordinary method of holding them between the thumb and finger, without occupying considerable time and frequently breaking them; may I venture to suggest that the following method, which I have adopted for some time, will, I think, be found a much easier, and at the same time a much safer way of effecting the above object?

After having washed the covers, I take two or three out of

the liquid and lay them on a piece of calico spread out on a table or other flat surface. I then remove most of the liquid from one of the pieces by rubbing it on the extended calico. Having removed most of the moisture in this way, I place the cover on a piece of buff about 10 inches long and 2 inches wide, fastened on a *flat* piece of wood of the same size, and by means of an old cambric handkerchief or bit of leather twisted round my fore-finger I rub it towards the other end, turning it in its course, when it will generally be found to be quite clean and fit to be put away ready for use at any time.

With a little practice this method will be found to be a very easy one, and attended with very little risk of breakage. —William Hodgson, 62, *York Street*, *Lambeth*.

Metallic impressions of Microscopic Objects.—The transparency of some microscopic objects frequently renders it a matter of difficulty to determine satisfactorily the details of their surface structure, or whether indicated lines, dots, or markings, are really dependent upon exterior configuration. Many of these objects, from their translucency, refract and reflect light, in such various directions, that their superficial formation becomes almost a matter of conjecture; neither is this doubt always to be resolved by viewing them as opaque objects, for in this case also, the same transparency prevents them from intercepting and dispersing a sufficiency of light, to render the question a conclusive one.

The siliceous valves of the *Diatomaceæ* are a class of objects peculiarly possessed of the above characteristics. It has long been a point of dispute, whether the markings which nearly all these objects display are invariably caused by projections on their surfaces, or by the mechanism of their internal structure. I have long been of the former opinion. A careful study of the coarser varieties will distinctly prove that the markings are raised ribs or prominences on the surfaces; in some instances occupying one side of the scale only, as seen in the *Campylodiscus spiralis*, and others. Though the microscope proves this fact satisfactorily in the large species, it fails to do so in the most difficult specimens, chiefly on account of the above-named deceptive appearances, arising from the irregular refraction and reflection of light.

It occurred to me that it might be possible to obtain a perfect cast or impression of the structure, and by viewing this as an opaque object, the errors of refraction would be avoided, and a discovery might be the reward of the experiment. I have succeeded in effecting this, by means of the

electrotype process, which, for many reasons, is to be preferred, as it does not distort the object, and is so minutely faithful, that even the mere trace of organic matter left by a slight finger-mark is perfectly copied. The method that I have adopted is this—procure a small plate of metal highly polished (a piece of daguerreotype plate answers extremely well), and after gently heating it, rub a piece of bees'-wax over the surface; while this is still melted, wipe it nearly all off again with a piece of rag, so as to allow a very thin film to remain. When the plate is cold, arrange the *Diatomaceæ* or other objects, previously moistened, upon the waxed surface, heat the plate again to at least 212°, in order to cement the objects on to it. The wax serves a twofold purpose—first its interposition prevents the possibility of a chemical union of the metallic deposit with the plate; and secondly, the object is securely held thereto by its agency. The objects are now ready to receive a coating of copper. If the battery is in good working order, three or four hours will give a film sufficiently strong to bear removal; when this is stripped off, if the process has been properly managed, the objects will be seen embedded in its surface. Whether they are siliceous or organic they may be entirely dissolved out, by boiling the cast in a test-tube, with a strong solution of caustic potash, and afterwards washing with distilled water; the copper film may then be mounted in Canada balsam.

By these means I have obtained distinct impressions of the markings of some of the more difficult *Diatomaceæ*, such as *N. Balticum*, *P. Hippocampus*, &c., leaving no doubt of their prominent nature. Care must be taken not to leave too much wax on the plate, or either a clean deposit will not be obtained, or the objects will be obscured by it. On the other hand, if too little is left, the copper will insinuate itself underneath the structure, and raise it from its place. Upon one occasion, I dried a section of wood on to a metal plate by heating it. In this state it appeared to be firmly adherent by its own resinous exudation. On placing it in connection with the battery over night, in the morning I found the bare section on the outside of the metallic deposit, upon which it had left a slight, though by no means a good impression. Even when a thin film of a non-conducting substance intervenes, the tendency of the deposit is to get as near as possible to the conducting plate, and in its endeavours to do so, it will fill every cavity and pore, however minute.

There is another method of obtaining metallic casts of minute objects that gives some curious results, and is, therefore, worthy of mention: it is done by stamping, or the same process in

miniature as that by which the plates of Auers' "nature-printing" are formed. Take some perfectly clean and bright tinfoil, three or four times doubled, and lay it upon a smooth block of metal. On the upper surface of the foil place the object; hold upon this a short steel punch with a highly-polished face, and strike it a smart blow with a hammer. In this way fish-scales, feathers, and sections, may be fairly impressed in the tin. For delineation of surface this process is not much to be depended upon; for if contiguous parts of the object are hard and soft, or more or less elastic, it will develop markings where they do not really exist. As an example, when a mouse hair was copied by the electrotype, it was shown to be nearly smooth, but when stamped into the foil, all its characteristic pigment-cells were displayed in the metal in a very beautiful manner. It has often been thought that these cells are real external cavities; which appearance is, doubtless, a deception of refraction. The last operation also displays some singular peculiarities in other animal hairs. I think that it would be an improvement to make use of a fly-press instead of the hammer and punch.—F. H. WENHAM.

Note on Dr. Griffiths' Paper on Angular Aperture.—We have received a communication from Dr. D'Alquen, containing "Further Remarks on Dr. J. W. Griffiths' Paper, on the Angular Aperture of Object-glasses, &c.," in which that gentleman complains in very strong terms of the way in which his objections are noticed by Dr. Griffiths in the Micrographic Dictionary, Art. Diatomaceæ, p. 203. And in support of his own views, he states that they had elicited the spontaneous approval of one of the best authorities on the subject, who had written to him to the following effect:—

"I have, however, to congratulate you upon the plain and matter-of-fact method by which you refuted Dr. Griffiths' visionary theory, and which I think he will find it difficult to answer, even if he should feel so inclined."—EDITORS.

ERRATA.

Page 110, line 35, for *solid*, read *sold*.
,, 119, ,, 36, *for* Plate IX. *read* Plate VII.
,, 124, ,, 22, *for* soniferous, *read* coniferous.

PROCEEDINGS OF SOCIETIES.

Microscopical Society. *December 27th*, 1854.

Dr. Carpenter, President, in the Chair.

A paper was read by the President, on the Development of the Embryo of *Purpura lapillus* (Transactions, vol. iii., p. 16).

J. Shuter, Esq., was balloted for, and elected a Fellow.

January 24th, 1855.

N. B. Ward, Esq., in the Chair.

A paper was read from Mrs. Herbert Thomas, on *Cosmarum margriatiferum*, and other Desmideæ.

Dr. Herapath, of Bristol, and J. E. Smith, Esq., were balloted for, and duly elected.

February 28th, 1855. Anniversary Meeting.

Dr. Carpenter in the Chair.

The Report of the Council was read. The President delivered an address.

F. C. Hills, Esq., Charles L. Leaf, Esq., Dr. F. Degrave, and R. C. Griffiths, Esq., were balloted for and elected.

The ballot for officers resulted in the re-election of Dr. Carpenter, President; N. B. Ward, Esq., Treasurer; and J. Quekett, Esq., Secretary.

The following gentlemen were added to the Council:—J. N. Furze, Esq., H. Perigal, Esq., Jun., Rev. J. B. Reade, and J. B. Simonds, Esq.

Royal Society.

"*Micro-chemical Researches on the Digestion of Starch and Amylaceous Foods.*" By Philip Burnard Ayres, M.D., Lond. Communicated by John Bishop, Esq., F.R.S. Received January 11, 1855.

After some general historical remarks on the methods hitherto employed in the investigation of the complicated phenomena of the process of digestion, the comparatively small results obtained by chemical analysis of the contents of the stomach, intestinal canal, and of the evacuations, by Tiedemann and Gmelin, Berzelius, and others, the author proceeded to demonstrate the necessity of a minute examination of the contents of the alimentary canal by the microscope, and such chemical tests as we possess for the determination of the changes of such articles of food as exhibit definite structure.

In order that we may ultimately arrive at a complete exposition of the phenomena of digestion, he is of opinion that it will be necessary to examine,—first, the structure of particular kinds of food, then the changes produced in them by cooking, and lastly to trace the changes they undergo at short intervals, through the alimentary canal from the stomach to the rectum. The results of a series of

researches of this character on the changes in starch, and starch-containing foods, are presented in this memoir.

The method adopted for the examination of the changes in starch and starch-foods was as follows:—an animal was kept fasting twenty-four hours, and afterwards confined to a diet consisting of the starch or amylaceous food, with water, for five or six days, until the debris of all other kinds of food previously taken were cleared from the alimentary canal. At a determinate time, after a meal, the animal was killed, the abdomen laid open as quickly as possible, and ligatures placed at short intervals on the intestinal canal, from the pyrolus to the rectum. The contents of the stomach and each portion of the intestinal canal included between the ligatures was then carefully examined. This mode of examination sufficed to determine the changes which occur in the food during normal digestion; but other questions as to the particular secretion or secretions by which the changes observed were effected.

The fluids poured into the alimentary canal are five in number,—the saliva, gastric juice, bile, pancreatic juice, and finally, the intestinal mucus.

The influence of the saliva is easily determined, by chewing the particular food subjected to experiment, and keeping the mixture at about 98° Fahr. The combined action of the saliva and gastric juice is seen in the contents of the stomach. To determine the action of the bile, the common bile-duct was tied, and to ascertain the action of the intestinal mucus, it was necessary to ligature the bile and pancreatic ducts. If the digestion of the substance is not effected in the stomach, it is evident that it cannot be attributed to the saliva or gastric juice; if the digestion is still effected in the intestinal canal after ligature of the bile-duct, it cannot be attributed to the action of the saliva, gastric juice or bile; if it still go on after ligature of the bile and pancreatic ducts, the digestive power must of necessity be referred to the action of the intestinal mucus, provided no change has previously taken place in the stomach; but if the food passes unchanged after cutting off the supply of bile and pancreatic juice, but proceeds after ligature of the bile-duct alone, the act of digestion must be referred to the pancreatic juice.

The author first briefly describes the structure of the starches and starch-containing vegetables employed in his experiments; then the changes produced by cooking, and finally enters on a minute description of the changes observed in the experiments he performed on normal digestion, and after cutting off the supply of bile and pancreatic juice.

The correct appreciation of the structure of the starch-granule is of considerable importance in relation to these investigations, and the author believes that he has been able to afford a satisfactory solution of this vexed question. The changes observed during the digestion of starch favour the original opinion of Leuwenhoeck, that the starch-granule consists essentially of an investing membrane or cell-wall, enclosing an amorphous matter, the true starch, which strikes an intense blue colour with iodine; and these changes also support the opinion of Professor Quekett, that the concentric circles

seen on the starch-granules of many plants are simple foldings of the investing membrane, leaving it still doubtful, however, whether these concentric circles are not in the starches of some plants composed of linear series of dotted elevations or depressions of the investing membrane.

By these experiments it was determined that the concentric circles remain after the whole of the starch matter, colourable by iodine, was removed, and that even then the characteristic cross and colours were still seen when the granules were viewed by polarized light, although more feebly than before; this result being probably due to the lessened power of refracting light, after the removal of the starch matter.

After describing the structure of the wheat-grain and flour, the changes occurring in the wheat-starch during the manufacture of bread are given in detail; but the most interesting of the changes produced by cooking are those seen in the boiled or roasted potato and in the boiled pea.

In each of these the act of cooking effects two purposes:—it causes great enlargement and physical change of the starch-granules, and dissolves the intimate adhesion of the starch-cells, which afterwards appear as ovid or globular, slightly adherent bodies distended by the swollen starch granules, the outlines of which are indicated by more or less irregular gyrate lines, produced by the mutual compression of the starch-granules within an inelastic cell-membrane.

The starch-granules of the pea possess a much thicker investing membrane than those of the potato, which causes their outlines to remain much more distinct after the removal of the true starch substance during the process of digestion. The other structures seen in the pea are carefully described; the most curious among them being the cells composing the external layer of the testa, which bear so strong a resemblance to columnar epithelium of the intestine, that they might be mistaken for the latter by an inattentive observer.

The substances submitted to experiment were,—1, boiled wheat-starch; 2, wheaten bread; 3, uncooked tous les mois; 4, boiled tous les mois; 5, boiled potato; 6, uncooked peas; 7, boiled peas; 8, boiled peas after ligature of the bile-duct; 9, boiled potatoes after ligature of the bile and pancreatic ducts. Several subsidiary experiments were made to determine the action of the intestinal mucus, the saliva, and the substance of the pancreas, on starch.

The conclusions at which the author arrives from the experiments are,—

1. That the starch-granule is composed of two parts, chemically and histologically distinct,—a cell-membrane and homogeneous contents. The markings seen on many varieties of starch are referred to folds or markings of the investing membrane.

2. No perceptible change occurs in the starch, whether raw or cooked, during its sojourn in the stomach of quadrupeds or the ventriculus succenturiatus and gizzard of birds; all the granules preserve their perfect reaction with iodine and their pristine appearance.

3. The conversion of boiled starch into dextrine and glucose is chiefly effected in the first few inches of the small intestine, but it continues to take place in a less degree throughout the entire intestinal canal.

4. In the digestion of boiled wheat or other starch, or of wheaten bread, the bulk of the mass rapidly diminishes in its passage through the small and large intestines, so that it ultimately yields only a small quantity of fæcal matter. After being deprived of their contents, the membranes of the granules shrink and shrivel up into a minute granular matter, which constitutes the chief bulk of the fæcal evacuations after an exclusive diet of starch food.

5. The digestion of raw starch food (peas) in the pigeon or other granivorous birds goes on much more slowly, and progresses pretty equally throughout the entire intestinal canal. The starch-granules, whether free or included in cells, become intersected by radiating or irregular lines or fissures, more or less opaque or granular ; they also gradually lose their characteristic reaction with iodine ; and this important change, commencing at the surface, progresses towards the centre, until the whole of the starch matter is removed, leaving the starch-membranes often apparently whole, retaining their characteristic markings. The fissured and granular condition of the starch-granules is not due to their trituration in the gizzard, but to the action of the intestinal fluids, since it was often seen in granules enclosed in and protected by perfect starch-cells. In the digestion of raw starch food, a considerable quantity always escapes change, for many starch-cells and granules in the fæces perfectly retain the characteristic reaction with iodine.

6. As the starch remains unchanged in the stomach, its conversion into glucose cannot be attributed to the saliva or gastric juice, unless we suppose these fluids to remain inactive in the stomach, and suddenly to regain their activity in the first part of the small intestine. The author found that the saliva was capable of effecting the conversion of starch into glucose, but that the mixture of saliva and gastric juice in the stomach did not possess that property even after being rendered alkaline by carbonate of soda. It is probable that the converting power of the saliva, as it flows from the mouth, depends not on the true saliva, but on the buccal mucus ; for Magendie found that saliva taken from the parotid duct was wholly inactive, while the mixed saliva from the mouth effected the conversion with great facility. Unless, then, the sublingual and submaxilliary glands secrete a different fluid from the parotids, it is evident that the activity of the saliva must be attributed to the buccal mucus.

7. The difference between the digestion of boiled and raw starch in dogs is seen in the experiments on the digestion of boiled wheat-starch, boiled tous les mois, and bread. In all these, some starch-granules escape the action of heat and water, and remain in nearly their pristine condition. These uncooked starch-granules undergo slow and imperfect changes, being fissured, broken, and more or less altered, but, in general, retaining their characteristic reaction with iodine.

8. The conversion of starch into glucose is not effected by the

bile, since after ligature of the common bile-duct, the changes occur to as great an extent as when the bile passes freely into the intestinal canal.

9. It is not due to the pancreatic juice, inasmuch as after ligature of the bile and pancreatic ducts in the same animal, the digestion of starch is still effected.

10. The only remaining secretion is the intestinal mucus, which is especially abundant at the upper part of the intestinal canal; and a further proof is afforded of the activity of the intestinal mucus taken from the upper part of the duodenum above the entrance of the pancreatic duct after ligature of this duct and the common bile-duct, by its capability of converting a large quantity of fresh-boiled starch into glucose out of the body.

11. In the cooking of starch-containing vegetables, such as potatoes and peas, the adhesion of the starch-cells is dissolved or weakened so as to render them easily separable and amenable to the action of the intestinal fluids. At the same time the starch-granules undergo a large increase in bulk, distend the cells, and by their mutual compression, their outlines present the appearance of gyrate lines beneath the cell-wall. The cells seldom burst so as to emit their contents, or present any appreciable opening through which the intestinal fluids can directly penetrate. The author cannot positively affirm so much of the starch-membranes, because these are so extremely delicate that fissures might be invisible, but he believes that in a great number the membranes remain entire.

12. If this be the case, the conversion of starch matter into glucose must be effected by the permeation or endosmose of the intestinal fluids through the invisible pores of two membranes, in the digestion of the pea, the potato, and other similar foods, and the glucose must escape through the same membranes by exosmose.

13. Before the conversion of starch into glucose, the amylaceous matter contained in the starch is more dense than the intestinal mucus in immediate contact with the cells, and an inward current or endosmose is established; but after that conversion the syrupy fluid is less dense than the mucus, and then an outward current or exosmose occurs, by which the glucose escapes from the cells into the intestine and is absorbed. If this be the case, as the details of the experiments tend strongly to prove, a new and important function is assigned to the intestinal mucus.

14. In normal digestion, chyme escapes very slowly from the stomach into the duodenum, in small quantities, as it is detached from the alimentary mass by the muscular movements of the stomach, and this gradual propulsion often occupies several hours after a meal. This slow propulsion is evidently intended to expose the comminuted food fully to the action of the intestinal juices, and produce an intimate mixture with them. The comparatively empty condition of the upper part of the small intestine, even during active digestion, is thus fully explained.

15. If the food be too finely divided or incapable of a second solidification in the stomach, it passes too rapidly into the first part of the small intestine, is insufficiently mixed with the intestinal

fluids, and a considerable part escapes digestion. On the other hand, if it enters the small intestine in masses incapable of reduction by the muscular action of the parts or solution in the fluid, it traverses the intestinal canal unchanged, except at the surface, which is then alone exposed to the action of the intestinal fluids.

16. It is not necessary for the conversion of starch into glucose that the fluids in the duodenum or other parts of the intestinal canal should be alkaline, or even neutral, for in several of the experiments the contents of every part of the alimentary canal had an acid reaction.

17. The greater part of the intestinal mucus is not excrementitious, for little, if any, mucus is perceptible in the fæces in normal digestion, except at their surface, whereas the greater proportion of the contents of the small intestine consists of mucus. A considerable quantity of mucus is seen in the cæcum, but it rapidly diminishes in the colon, and is scarcely detectible in the fæces, except that on the surface, which is probably derived from the mucous membrane of the rectum. The author raises the question, whether one of the chief functions of the cæcum is not to effect the conversion of the intestinal mucus into some other substance capable of re-entering the blood, and performing some ulterior purpose in the animal economy.

18. In normal digestion, the separation of the epithelium of the mucous membrane of the intestine is the exception instead of the rule, as stated by some physiologists. The author questions the theory of the detachment of the epithelium of the villi in each act of absorption, on the grounds that the presence of detached epithelium was unfrequent in the whole course of his experiments; that epithelium is readily detached by manipulation; that the continual reproduction of such a vast amount of cell-tissue must necessarily be accompanied by a vast expenditure of vital force; and finally, that it is not necessary, because fluids readily penetrate epithelial membranes.

19 The passage of a given food through the whole length of the intestinal canal may occupy a comparatively short time, especially when the animal is fasting. In one experiment, where a pigeon refused food until the fæces contained no visible debris of previous food, starch-granules were detected in the fæces within two hours after a meal, and this although the intestine of this animal is extremely narrow, and about a yard in length.

20. A remarkable circumstance in the digestion of starch or starch foods is the constant presence of myriads of vibriones in the lower part of the intestinal canal. They are generally first observed in the lower part of the small intestine, as minute brilliant points, just visible with a power of 600 diameters, in active movement. They increase in numbers towards the cæcum, in which a large number of fully-developed vibriones are constantly seen. These minute organisms increase in size and length in the colon and rectum, and their fissiparous mode of propagation, first described by the author in the 'Quarterly Journal of Microscopical Science,' may be distinctly traced by examining the contents of these portions of the intestine.

ZOOPHYTOLOGY.

UNDER the above not very scientific term, it is our intention to devote in each number of the Journal one, two, or more plates, as occasion may require, illustrative of new forms belonging to the various classes of animals included under the vague though popularly well understood term of Zoophytes; or, more particularly, of those among them which from their size are necessarily subjects of microscopic research. These are principally the Hydrozoa or Anthozoa hydroida of Dr. Johnston. The Asteroid and Helianthoid divisions, scarcely requiring the microscope for their determination, are not included in our design.

In this department of the Journal we shall give—1. Figures and descriptions of new or hitherto undescribed species from any part of the world, as they may come under our observation or be furnished to us by others. We should therefore be obliged to those who take an interest in this branch of Zoology to aid us by the communication of such observations, with respect to new forms, as they may be desirous of presenting to the world. 2. Observations on the anatomy and physiology, &c., of the creatures comprised in the scope of our design, illustrated or not. And 3. Notices of new species or original observations published elsewhere.

As one very important, if not the most important, object of this undertaking is to assist in the arriving ultimately at some correct notions with respect to the geographical distribution of these creatures—a problem apparently of the most curious kind; it is highly desirable that any localities should be assigned only upon good authority, and, if possible, accompanied with particulars as to the depth, bottom, and nature of the surface upon which the polypidom or polyzoary grows. Specimens for the purpose of representation, or drawings, will be duly preserved and returned.

In the present number we commence with an enumeration of Zoophytes of the two classes of animals above mentioned, collected in the Arctic seas. The majority were brought home by Dr. Sutherland, surgeon to H. M. S. Sophia; others by Sir E. Belcher, in what may perhaps be the last of Arctic voyages; and for two specimens we are indebted to our friend, Mr. C. Peach, whose well-known accuracy is a sufficient guarantee for the correctness of the habitat.

Even in this limited though interesting collection, it will be seen that several new and remarkable forms are contained,

and that other wide-spread species, though extending through the torrid, despise the utmost rigours of the Arctic zone.

The arrangement of the Polyzoa, which it is purposed here to adopt, is that according to which the marine Polyzoa are disposed in the catalogue of those in the British Museum, drawn up by Mr. Busk; the names of already-known species are those there employed, where also figures of every species, and the synonymy will be found.

Class. POLYZOA.

Order I. P. INFUNDIBULATA.

Sub-order 1. CHEILOSTOMATA.

§ 1. Articulata.

§§ 2. Bi-multiserialaria.

1. Fam. SALICORNARIADÆ.

1. Gen. Salicornaria, Cuv.

1. *S. borealis*, n. sp. Pl. I., fig. 1, 2, 3.

Front of cell elongated, slightly contracted below, arched above; surface and raised margin smooth; avicularium on the front of the cell near the bottom; mandible triangular, acute, pointing downwards.

Hab. West Greenland, 73° 20′ N. 57° 20′ W., 6 to 10 fms. Dr. Sutherland.

A very distinct and well-marked form. The polyzoary, which is composed of club-shaped internodes, varying greatly in size, is irregularly dichotomous, and from one to two inches in height.

Fam. CELLULARIADÆ.

2. Gen. Menipea, Lamx.

1. *M. arctica*, n. sp. Pl. I., fig. 4, 5, 6.

Cells 3—9 in each internode, rhomboidal; aperture oval, contracted below; a marginal spine on each superiorly; central cell at a bifurcation mucronate at the summit. Ovicell smooth.

Hab. W. Greenland, 73° 20′ N. 57° 20′ W., 6 to 20 fms. Assistance Bay, 74° 50′ N. 94° 16′ W., 15 fms. Dr. Sutherland.

This species, which at first sight much resembles a Cellularia, differs from all its congeners with which I am acquainted in the absence of any avicularium on the anterior aspect of the cells. The lateral avicularium is also frequently absent, and fragments thus unfurnished could only be distinguished from the genus Cellularia by the rhomboidal form of the back of the cells, and the absence of the perforations which exist on the back of the cells in all species properly belonging to that genus.

Gen. 3. Scrupocellaria.

1. *S. scrupea?* B. M. Cat., p. 24. Pl. XXI., fig. 1, 2.

Hab. Arctic sea. Sir E. Belcher.

The determination of this form having been made from only a very minute specimen, growing on the inside of a valve of *Terebratula psittacea*, is not absolutely certain, but I have little doubt of its correctness.

§ 2. Inarticulata seu continua.

§§ 1. Uniserialaria.

Gen. 4. Hippothoa, Lamx.

1. *H. divaricata*, Lamx. B. M. Cat., p. 30. Pl. XVIII., fig. 3, 4.

Hab. Arctic sea. On valve of *Terebratula psittacea*. Sir E. Belcher.

Fam. Membraniporidæ.

Gen. 5. Membranipora, Johnst.

1. *M. Sophiæ*, n. sp. Pl. I., fig. 7.

An avicularium on either side, on the margin of the aperture. Two marginal spines on either side below the avicularia.

Hab. Assistance Bay (*ut supra*). On fucus. Dr. Sutherland.

The species to which the present form most nearly approaches are—

M. Flemingii, B. M. Cat., p. 58.
M. lineata, Linn.
M. fallax, Fleming.

From the first of these it is distinguished by the position of the avicularia and the number and situation of the marginal spines. From the second by the small number of the spines, and the position of the avicularia. From the third, about whose distinctness Dr. Johnston, as I think erroneously, appears to have doubts, by the number and situation of the avicularia, and the number and situation of the marginal spines. Of the three it most nearly approaches *M. Flemingii*, but I entertain no doubt of its distinctness.

2. *M. Flemingii*. B. M. Cat., p. 58. Pl. LXI., fig. 2; Pl. LXXXIV., fig. 4, 5, 6; Pl. CIV., fig. 2, 3, 4.

Hab. Arctic sea. Sir E. Belcher.

Gen. 6. Lepralia, Johnst.

1. *L. hyalina*, Linn. B. M. Cat., p. 84. Pl. LXXXII., fig. 1, 2, 3; Pl. XCV., fig. 3, 4, 5; Pl. CI., fig. 1, 2.

Hab. Assistance Bay and W. Greenland (*ut supra*). On fucus. 6 to 20 fms.

This species, which is liable to numerous varieties, ranges from the Arctic almost to the Antarctic seas, and abounds in all intermediate latitudes. Its longitudinal range appears to be nearly equally extensive. It occurs, for instance, in the Falkland Islands, *Darwin*; Cape of Good Hope, *Harvey*; California, *Dr. Sinclair*; and is common in the seas of Europe.

2. *L. scutulata*, n. sp. Pl. II., fig. 1, 2.

Cells ovate; a scutiform or ovate space on the front, bounded by a raised line, within which the surface is punctate. Mouth rounded above, lower lip straight; a projecting rostrum below the mouth, sometimes absent. Ovicell .

Hab. W. Greenland (*ut supra*). On fucus. Dr. Sutherland.

A very peculiar and distinct form. It is remarkable by the circumstance that the cells gradually diminish in size from the centre to the periphery of the patch formed by the polyzoary.

Fam. Escharidæ.

Gen. 7. Eschara, Ray.

1. *E. cervicornis*, Ellis and Soland. B. M. Cat. Pl. CIX., fig. 7; Pl. CXIX., fig. 1.

Hab. Arctic sea. Sir E. Belcher.

The fragments collected, which are of some size, indicate that this species flourishes in full vigour in the Arctic ocean.

2. *E.* ? n. sp.?

Hab. Arctic sea. Sir E. Belcher.

This form, the determination of which has not been made as yet with sufficient certainty, appears to be new. The polyzoary is composed of

slender cylindrical branches. Its description and representation are reserved for a future occasion.

Sub-order II. Cyclostomata.

Fam. Tubuliporidæ.

1. Gen. Tubulipora, Lamk.

1. *T. ventricosa*, n. sp. Pl. II., fig. 3, 4.

Polyzoarium sub-erect or recumbent attached by a contracted stem, which rapidly expands above into a hollow calcareous vesicle, from which the tubes project irregularly and of various lengths.

Hab. W. Greenland (*ut supra*). On fucus. *Dr. Sutherland.*

Some of the simple forms of *T. serpens*, or *flabellaris*, might on occasion perhaps be confounded with the present species; but it nevertheless, from comparison of several specimens, appears to me to be quite distinct. The polyzoary, which, though recumbent, is usually wholly unattached above, is about 1-8th of an inch in length. It arises by a contracted portion or stem, which is usually more or less curved or contorted; and speedily expands into a wide ventricose dilatation, in which the upper tubes are immersed for a considerable part of their length. The tubes project irregularly from all parts of the exposed aspect of the polyzoary, and are themselves smooth or faintly ringed with lines of growth, whilst the surface of the vesicular dilatation, which doubtless corresponds with an ovicell, is finely punctate. When perfect the orifice of the tubes exhibits a tooth-like projection on one or two sides.

2. Gen. Discopora, Fleming. Pl. III., fig. 1.

1. *D. ciliata*, n. sp.

Orifice of tubes furnished with numerous slender spines.

Hab. Assistance Bay and W. Greenland. On fucus. Dr. Sutherland.

The figure of this minute species will be given in a subsequent plate. It bears a remote resemblance to *Discopora hispida* (*Tubulipora hispida*, Johnst.), but differs in the numerous slender spines with which the orifice of the tubes is furnished.

Class. HYDROZOA.

Fam. Sertulariadæ.

Gen. 1. Sertularia, Linn.

1. *S. polyzonias*? Pl. II., fig. 5, 6.

Hab. Greenland. Peach.

From the small specimen thus characterized, and which is unfurnished with the ovicell, it would appear that this cosmopolite species extends even into the Arctic circle. It seems to abound in all parts of the world.

2. *P. imbricata*, n. sp. Pl. II., fig. 7, 8.

Cells sub-opposite, very close, urceolate, wide and deeply immersed below; contracted and free for a short distance above; margin of mouth slightly raised on each side. Polypidom simply pinnate; pinnæ sometimes forked, long and drooping. Ovicell ?

Hab. Greenland. Peach.

I am unable to reconcile this form with any other, and therefore venture to give it the above designation.

ORIGINAL COMMUNICATIONS.

On the Structure *of the* Cutaneous Follicles *of the* Toad, *with some* Experiments *and* Observations *upon the* Nature *and alleged* Venomous Properties *of their* Secretion. By George Rainey, M.R.C.S., Lecturer on Anatomy, &c. &c., St. Thomas's Hospital.

From time immemorial a venomous quality has been attributed to one or other of the secretions of the toad. Scarcely any one who has spent much time in the provinces of this, and other countries, has failed to hear of instances of supposed poisoning by this reptile: these accounts, however, have always been so vague and imperfectly attested, as to obtain credit only among the uninformed and superstitious classes of the people, so that by enlightened persons the belief in the venomous powers of the Toad has been regarded only as a vulgar prejudice. Such were the doubts and opinions entertained upon this subject as late as 1851, when they were said to be set at rest, and the poisonous nature of the cutaneous secretion of the toad demonstrated by two French philosophers, MM. Gratiolet and S. Cloez, who, by inoculating various animals with the secretion in question, produced, according to the account given of these experiments, most decided results, and, in some instances, almost immediate death.

The experiments performed by these gentlemen were described in many of the periodicals of this country. The following are recorded in the 'Zoologist' for November 1852: "The first experiment was prosecuted on a little African tortoise, which was inoculated with some of the toad-poison in one of the hinder feet; paralysis of the limb supervened, and still existed at the expiration of eight months, thus demonstrating the possibility of local poisoning by the agent. In order to demonstrate whether the poisonous material spoiled by keeping, these two gentlemen procured about twenty-nine grains of the poison on the 25th of April, 1851, and having placed it aside until the 16th of March, 1852, they inoculated a goldfinch with a little of this material; the bird almost immediately died. Subsequently the investigators succeeded in eliminating the poisonous principle from the inert matters with which it is associated in the skin-pustules, and they found that when thus purified, its effects are greatly more intense than before." Although the only way to investigate

this subject so as to lead to the decision of this long-controverted question, is to repeat the experiments of these investigators under, as nearly as possible, the same circumstances as those under which they were performed, and note carefully the results, still there are some objections to the conclusions to which they seem to have arrived, which deserve to be noticed. With respect to the first experiment, as an isolated example, it, in my opinion, proves nothing positive, nor can it have any weight, unless a similar effect can be produced upon the same species of animal whenever the secretion is applied in sufficient quantities. The alleged facts of this secretion being, as it were, only a diluted kind of venom, and containing a poison separable by chemical reagents, seem at variance with the nature of organic animal venoms generally, such as that of the Viper, the Bee, &c., which, in their natural state, are sufficiently concentrated to produce the most unequivocal effects as animal poisons. Besides, organic poisons of this kind are most probably so easily decomposed, that the chemical means employed to isolate their poisonous principle, could scarcely fail to destroy its specific properties. But before describing the experiments which I have performed with the secretion of the toad's skin, with a view to test the accuracy of the above statements, I will give an account of the structure of the follicles by which it is secreted, this being the especial object of this communication, as I am not aware that these organs have ever been described. These bodies (Plate XI., figs. 1 and 2) exist in the form of vascular sacks, of various sizes, but largest about the sides of the head and back; they are situated in the very substance of the skin of this reptile; the vessels supplying them are altogether distinct from the capillary network on the surface of the skin, and have an especial arrangement and form of distribution by which their presence can be recognized. These follicles, though sufficiently characteristic, are difficult of demonstration, in consequence of being seen with perfect distinctness only in the skin of the Toad when injected with colouring matter and dried, and afterwards rendered transparent by immersion in turpentine or Canada balsam. This difficulty proceeds from the opacity of the portion of skin situated behind the follicle, preventing, whilst it is wet, the deep part of the follicle from being seen, whilst the cutaneous capillary network conceals the part of it nearest the surface. They are of a globular form when distended, but somewhat flask-shaped when empty (fig. 2). They range from 1-50th to 1-16th of an inch in diameter. About the centre of the cutaneous surface of each follicle there is an opening by which its cavity

communicates with the skin: this opening is small, compared with the size of the follicle, in the collapsed state of which it is partially closed, in consequence of the approximation of the folds of the internal membrane. This membrane, especially in the larger follicles, is seen in a horizontal section to be folded upon itself in a direction perpendicular to the surface of the skin (figs. 3 and 4), so as to present a number of imperfect septa projecting from the circumference of the follicle towards the centre, with lateral depressions, or saculi, between them. The whole of the internal surface of this membrane is lined with epithelium, consisting of delicate, lozenge-shaped, very flat cells (fig. 5), connected together by their edges, but presenting each a very sharp and well-defined margin, and one large nucleus. The nucleus contains minute granules, which, as the cells degenerate into a state of decay, can be seen to increase in size and distinctness, and ultimately to become broken up into the minute oily-looking granules (fig. 1), of which the secretion of the follicles is chiefly made up. The vessels of these follicles consist of capillaries of a larger size than those forming the plexus on the surface of the skin, and with much smaller areolæ; they do not follow accurately the folds of membrane projecting into the cavity of the follicles, but simply pass over, and on the outer side of these folds, so as to encircle the entire sack with a single layer of capillaries. The afferent and efferent blood-vessels of this plexus are connected with its deep surface, which, being generally only two in number, an artery and a vein, and give to the follicles, when minutely injected, very much the appearance of a Malpighian body highly magnified.

These follicles are entirely surrounded with the white fibrous tissue of which the skin is composed, excepting where they open on the surface. These fibres are disposed in two planes, one parallel with the surface, the other perpendicular to it; the former are by far the most numerous, and constitute the chief thickness of the skin; the latter are comparatively few, and only partially distributed, being collected into bands placed at nearly equal distances apart, which, extending through the entire thickness of the skin, from its deep to its superficial surface, draw, as it were, the fibres of the first set in these situations more firmly together; and thus producing a closer approximation of the fibres, and a corresponding diminution in the thickness of the skin at these parts, they cause the horizontal cellular fibres to take an undulating course.

Between the part of the true skin just described, and its epidermic surface, and immediately beneath the cutaneous capillaries, there is a layer of earthy matter, varying in thick-

ness in different parts of the animal, but present, I believe, in all. This part of the dermis is composed of irregularly-shaped masses of a semitransparent and highly-refractive material (fig. 4), looking like broken fragments of crystal or glass, lodged in cellular depressions of the true skin. Where the secreting follicles are situated, this earthy matter is placed superficial to them, so that their openings have to penetrate a layer of earthy substance, in order to reach the surface of the dermis. This part of the skin, when acted upon by acids, under the microscope is seen to effervesce briskly, and after all the earthy material is dissolved out, a membranous or animal basis is left. Probably this part of the skin in the Toad is analogous to the scaly covering of the Chelonian reptiles. According to Dr. Davy's analysis of the skin of the toad, it contains phosphate and carbonate of lime, and carbonate of magnesia. No organs like those which I have described as the cutaneous follicles of the Toad, exist in the integument of the Frog or Water-newt. In these reptiles the skin is much more simple, and all the vessels supplying it go into the common superficial plexus of the dermis. I have not examined the skins of those lizards whose habits resemble those of the toad, for the purpose of determining whether the same kind of follicles exist also in them.

With respect to the chemical and physical properties of the secretion of the Toad's skin, Dr. Davy observes, in a paper contained in the 'Philosophical Transactions,' for 1826, that the greater part of it is soluble both in alcohol and in water; that the substance obtained by evaporation, both of the aqueous and alcoholic solution, is slightly yellow, and has a faint and peculiar smell; that when heated it readily melts, and burns with a bright flame, but without emitting an ammoniacal odour; also that the secretion is slightly bitter, and very acrid, acting on the tongue like the extract of aconite, and even occasioning a smarting sensation when applied to the skin of the hand, which lasted for two or three hours; that it does not affect the colour of litmus, or turmeric paper. This secretion, though possessed of these decidedly acrid properties, even in a much greater degree than the poison of the most venomous snakes, was not found by Dr. Davy to produce any injurious effects when applied to a wound on a Chicken, made with a lancet dipped in it; and hence it seems to be endowed merely with irritating qualities, and not to possess the venomous properties attributed to it by the French investigators.

The experiments which I have performed upon living animals with this secretion, have in no instance agreed in their

results with those recorded by Gratiolet and Cloez. I applied some of the fresh secretion to a recent wound on the ear of a Kitten, but it produced no sensible effect. I also inoculated Toads both with their own secretion, and that taken from other toads, but it did not affect them. White mice were inoculated with it in various ways, but they sustained no apparent injury. In order to secure the perfect contact of the secretion with the wounded surface, I immersed a piece of thread in the fresh fluid of a follicle, and passed it through the skin of a Mouse in the manner of a seton, where it remained for several days, but without producing any perceptible harm to the little animal. It is remarkable that such different results should be obtained from the same description of experiments, and it is very difficult to reconcile these discrepancies. It is true that the single example which Dr. Davy has recorded, and those which I have mentioned, are on the negative side of the question, and therefore cannot be looked upon as so conclusive as those on the positive side. However, I think these experiments are sufficient to throw considerable doubt upon the accuracy of the conclusions of the French investigators, and to bring the question into the same state of uncertainty that it was before their observations were published, where it must remain until these authors shall be able so to conduct their experiments, as at all times to produce the effects they have described, or, in case of failure, to give a satisfactory explanation of its cause. There is one consideration which, as mere circumstantial evidence, may be mentioned in opposition to the view of the intensely-venomous power of the secretion of the Toad's skin, and that is its general diffusion over a large part of the body, whilst in all those animals which are decidedly provided with a specific venom, and not a mere irritant, the frightful apparatus which produces and applies it, is well known to occupy only a very confined locality.

From what has been stated it appears, then, that though the specific character of the secretion in question, as a venom, is very questionable, yet that it certainly does possess an irritating quality, as was apparent from its action when applied to the skin, and more especially to the tongue; hence Dr. Davy thinks that its principal use is to defend the reptile against the attacks of carnivorous animals. The extremely dense structure of its dermis, approaching in its composition to that of bone, is, I think, somewhat in favour of this opinion, as affording also, more or less, a means of protection and defence. Dr. Davy also considers that, as the secretion contains an inflammable substance, it may serve to carry off a

portion of carbon from the blood, and thus be auxiliary to the function of the lungs. In support of this idea the same author observes that each of the pulmonary arteries of the Toad divides into two branches, one of which goes to the lungs, the other to the cutis, ramifying most abundantly where the largest follicles are situated, and where there is a large venous plexus, seeming to indicate that the subcutaneous distribution of the second branch of the pulmonary artery may further aid the office of the lungs by bringing the blood to the surface to be acted upon by the air. However, it seems to me that if these follicles aid at all the lungs, it can only be by eliminating carbon set free in other organs of the body, and then conveyed into the blood, from whence they afterwards excrete it; as the deep position of their capillaries, and the secretion with which they are always more or less thickly covered, will make them inaccessible to the atmospheric air, and therefore, in this respect, render them altogether different from the cutaneous capillaries which are placed superficial to the earthy layer of the dermis, and in which the blood is perhaps acted upon, as above intimated. But I cannot help thinking otherwise than that these follicles have something to do with the absorption, and more especially with the retention, of the fluid which, in this class of reptiles, is taken into the system by the skin. In the Frogs there is a superficial plexus of capillaries the same as in the Toads, by which the absorption of the fluid in contact with the surface, can take place equally in either case; but in the former animal there are no cutaneous organs which could in any manner aid in the retention of that fluid, so that this reptile requires more frequently than the toad a fresh application of moisture to its surface; and besides, if the Frog be exposed to the absorbent power of dry mould, as the Toad frequently is, the greater part of the fluid contained in its vessels will immediately pass off through the skin into the dry earth in consequence of its greater capillary attraction, and the animal will very soon die from a kind of inanition. This fact I have verified by placing fine dry sand in contact with the skin of Frogs, which so rapidly absorbs their moisture that they die in a few minutes. The contents, also, of the follicles of the toad, mixing with the dust and other extraneous substances constantly in contact with its skin, especially as this secretion is of a very glutinous nature, and has a tendency to coagulate when wetted, may possibly form a coating on its external surface, and thus tend to diminish evaporation; and in this way it may assist in retaining the fluids absorbed into the body, and in preventing its desiccation, and thus furnish another

means of adapting this animal to the physical and physiological states and conditions under which it is constrained to live, and to perform its part in the accomplishment of that one universal and wise purpose for which this much-despised reptile, in conjunction with all other living beings, was designed and created.

On the Reproductive Organs *of certain* Fungi. By Frederick Currey, Esq., M.A.

The existence of sexual organs in the lower orders of plants is a question which of late years has attracted much attention amongst botanists, and it is one upon which the powers of the microscope have been brought to bear with the happiest results.

The investigation has already been carried sufficiently far to show that many of the plants hitherto ranked in the Order of the *Cryptogamia* can with difficulty be denied the right of being considered phanerogamic; and there seems good reason to hope that before many years have elapsed, the term *cryptogamic* will have ceased to be applicable to any portion of the vegetable world.

It is hardly too much to assert that sexuality is already established in the *Fucaceæ* and *Characeæ* amongst the *Thallogens*, and in the Liverworts, Scale-mosses, Urn-mosses, Club-mosses, Horse-tails, and Ferns amongst the *Acrogens*, although there are not wanting botanists of eminence who either deny the fact, or, at least, admit it only with the doubts of an imperfect faith.

In Lichens, M. Tulasne has demonstrated the existence of certain organs to which he has given the name of *spermogonia*. These spermogonia are the small black specks seen on the shields of Lichens, and are small conceptacles, or cases, containing a prodigious quantity of minute spore-like processes, to which the name of *spermatia* has been given. The spermatia are very minute linear bodies, sometimes curved and endowed with molecular movement. They are produced either upon the apices of the cellules which form the walls of the spermogonium, or sometimes laterally from moniliform filaments or other processes which line the cavity of the spermogonium.

The functions of the spermatia are as yet unascertained, although from their universal presence, and the circumstance of their appearance prior to the perfect, or the casporous fructification, it is suspected that they may eventually prove to be the male organs of that class of plants.

There are many Fungi in which bodies analogous to the spermogonia and spermatia of Lichens are found to exist, and as far as present observation has extended, these bodies are found to precede the formation of the perfect spores. The genus *Æcidium* is very favourable for an examination of these organs. The spermogonia occur in spring upon those parts of the plants upon which perfect *Æcidia* are afterwards found; they are in the form of minute punctiform specks, covering the pale or red spots upon which the *Æcidia* are at a later period produced. A microscopical examination of these specks shows them to be globular bodies, open at the top, having their walls composed of densely-interwoven threads originating from the mycelium, and containing in their interior other threads converging towards the centre of the spermogonium, and bearing spermatia at their apices. The spermatia are produced in great abundance, and form a granular mass, filling the hollow of the spermogonium. The upper threads of the walls (namely, those which are situated next to the apicular opening of the spermogonium) are somewhat more upright than the others, and are directed towards the epidermis of the surface of the leaf; and by the growth of these upper threads and the increase of the granular mass of spermatia, the spermogonium increases in size, raises, and eventually breaks through the epidermis, the outermost threads forming a small red funnel-shaped tuft, through which the spermatia eventually escape, and are dispersed around the spermogonium. After the ripening of the spermogonia, the perithecia of the true *Æcidia* are formed *on the same mycelium*, and the spermogonia then decay.

Spermogonia, such as those just described, are not confined to the genus *Æcidium*; they are common to other genera in the tribe of the *Uredineæ*, occurring in *Cæoma*, *Ræstelia*, *Peridermium*, *Phragmidium*, *Triphragmium*, and *Puccinia*. In *Cystopus*, *Melampsora*, *Coleosporium*, *and Uromyces*, they have not as yet been ascertained to exist. Nor are spermogonia peculiar to the tribe of the *Uredineæ*; they occur with certain, but not essential differences of structure, in many other Fungi. It has been shown by the observations of Fries, Tulasne, and other mycologists, that several sorts of Fungi, long supposed to form distinct genera, are, in fact, only early states of other well-known plants: thus the genera *Septoria*, *Cytispora*, *Nemaspora*, *Hendersonia*, and others, are now considered to be the spermogonia of species of *Sphæriæ*; *Melasmia* is supposed to be the spermatiferous state of *Rhytisma*; *Leptostroma* probably of *Hysterium*, *Phacidium*, etc. . . .

In a paper published in the 'Annales des Sciences' for

1853, M. Tulasne has given a description of a considerable number of Fungi belonging to the order of the *Discomycetes*, in which he has observed spermatia; and he states that he has also discovered them in several of the *Pyrenomycetes*. The details of his observations on the latter tribe have not, as far as I am aware, been yet made public, although referred to in a paper in the 15th volume of the 3rd series of the 'Annales des Sciences.'

I have already stated that the functions of the spermatia of Lichens are not yet ascertained; and as in the vast family of the Fungi there are as yet comparatively few species in which these organs have been certainly observed, it is obvious that we are not yet in a position to hazard an opinion as to the office which they fulfil in the latter tribe. All mycologists will, I am sure, agree with M. Tulasne, who has remarked that the present aim of observers should be to ascertain whether *spermatia* exist in a sufficient number of species to consider them *constant* or common to all. The subject of their *action*, supposing them to be male organs, might be afterwards considered.

Whilst the observer is occupied in investigating the nature of the spermatia, he will naturally and necessarily be led into an inquiry into the nature of two kinds of reproductive organs distinct from the spermatia, and which are called *stylospores* and *conidia*.

It has been found that in some ascigerous Fungi, that is, Fungi in which the normal fructification consists of spores contained in asci or thecæ, there are produced other *naked* spores which are borne upon pedicels of greater or less length, and it is these naked spores to which the name of *stylospores* has been given. The cellules or pedicels upon which the stylospores are borne, are analogous to the basidia of the *Agaricini*: they are sometimes enclosed in a conceptacle, or case, which is called a *Pycnidium*.

Size and complexity of structure generally distinguish the stylospores from the spermatia; but there is no very definite line of demarcation, so far as regards structure, between *spermatia* and small simple *stylospores*.

The term *conidia* was applied by Fries to all reproductive bodies not being normal spores.

Tulasne restricts it to *Gemmæ* properly so called, that is to say, reproductive cellules growing directly from the mycelium.

I will now proceed to state the result of some observations with which I have lately been occupied, bearing upon the matters above alluded to.

1. *Sphæria herbarum Pers.*—This very common but beautiful *Sphæria* is to be found abundantly in spring in the form of small black specks upon the dead stems of herbaceous plants. About the beginning of March in the present year, I observed that the dead stems of some plants of *Senecio Jacobæa* were covered with a Fungus, the perithecia of which formed minute black spots so small as not to be visible without close inspection. In Plate XII., fig. 1, one of these perithecia is represented with its mycelium magnified 110 diameters, and fig. 2 represents a transverse section of a similar perithecium, the interior being filled with small spore-like bodies proceeding from the somewhat-pointed cells which lined the cavity of the perithecium. According to the principles of classification hitherto adopted, the plants would have belonged to the genus *Sphæropsis;* but being desirous of ascertaining whether it might not in fact be only an early state of some other Fungus, I placed some pieces of the dead stems upon damp *Sphagnum* moss, and covered them with a bell-glass. In about a fortnight I found the under surface of the stems (*i. e.*, that part of them which had lain in contact with the damp moss) covered with a crop of small black *Sphæriæ.* There was, therefore, some reason for supposing that the *Sphæropsis* was only a predecessor of the *Sphæriæ;* but as there were three, if not four, different species* of the latter, it would have been impossible to determine to which of them the *Sphæropsis* belonged, had it not been for the form of the mycelium. In examining the *Sphæropsis*, I had particularly observed its mycelium, which was unusually large compared with the size of the perithecium, and had moreover the peculiar knotty appearance shown in figs. 1 and 2. Upon comparing this mycelium with that of *Sphæria herbarum*, the two appeared identical; and as the same mycelium was not to be seen in connection with the other *Sphæriæ*, it seems fair to conclude that the supposed *Sphæropsis* was the spermogonium of *Sphæria herbarum.* The question then arises whether the spermogonium in this case be a distinct organ on the same mycelium, or whether the same perithecium produces in the first instance the spermatia, and subsequently the perfect fructification, that is, asci containing sporidia. In the *Æcidia,* as we have seen, the spermogonia are quite

* The species appeared to be the following:—*Sphæria comata, capillata, herbarum*, and *complanata.* I doubt if the two former are distinct; I found the sporidia precisely alike, and the only difference was in the colour of the hairs on the perithecia, which were black, or nearly so, in *S. comata*, and greenish in *S. capillata.* The difference in the colour of the hairs would hardly justify a separation of the species.

distinct from the true Æcidineous perithecia; but there are some discomycetous Fungi, for instance, *Peziza benesuada*, *Cenangium Frangulæ*, and *Dermatea carpinea*, in which the spermatia and the perfect fructification occur in the same part of the plant. From what will be stated hereafter, with regard to *Sphæria complanata*, it would seem that in the latter plant the same perithecium produces spermatia and asci successively; and if it be allowable to assume a law for the genus from what occurs in one species, it would follow that the spermogonium in *Sphæria herbarum* is not distinct from the true perithecium.

It will be proper here to mention certain other reproductive bodies which I have observed in *Sphæria herbarum;* they are somewhat irregular in colour, shape, and size, and grow directly from the mycelium. In colour they differ much amongst one another, varying from a dull brown to the bright yellow of the normal sporidia. In fig. 3 several of these bodies are represented; some of the larger of them strongly resemble the spores of a *Stemphylium* or *Sporidesmium*, and others again are hardly distinguishable from the regular sporidia of *Sphæria herbarum*. These bodies come under M. Tulasne's definition of conidia, being gemmæ or buds proceeding directly from the mycelium.

Those represented in fig. 3 occurred in company with full-grown, ripe perithecia; but their growth commences at a very early period, and contemporaneously, or nearly so, with the appearance of certain other bodies, which may also, perhaps, have to be ranked amongst the varieties of fruit of *Sphæria herbarum;* these last-mentioned bodies are globular vesicles, which proceed from the end of short branches of the mycelium in its earliest stage.

The sporidia of *Sphæria herbarum* appear to have a great facility of germination, throwing out filaments from several different partitions of the sporidia. On the 2nd of May in the present year, I had placed a section of a perithecium upon a slide under a piece of thin glass, for examination in the usual way, and the fruit being particularly fine, I put the slide upon damp moss under a bell-glass, with the view of keeping the object moist until a drawing could be made. The weather was very unfavourable for germination, for the long-prevalent east wind was on that day more than ordinarily harsh and cutting, and Fahrenheit's thermometer fell at night to 26°; moreover the room in which the slide was kept had a northern aspect, no fire, and the character of being at all times cold. Notwithstanding these circumstances I found, upon examining the slide the next morning (May 3), that the sporidia had ger-

minated in the greatest abundance; and not only had the free sporidia—those which had escaped from their asci—thus sprouted, but those which were still enclosed had also sent forth their germ-filaments, which had penetrated the membrane of the asci in all directions.

In fig. 4, I have represented one of the asci in which nearly all the sporidia have begun to grow, and other asci in the neighbourhood were even more densely covered with filaments than the one shown in fig. 4. On the following morning (May 4) the germ-filaments had reached a considerable length, and had become branched and indistinctly septate in several places (see figs. 5 and 6), as indeed was the case on the previous day with some of the more advanced shoots. At one point the germ-filament had protruded short branches at right angles to the main filament on either side (see fig. 5), and at the end of each of these short branches was seated one of the globular vesicles above mentioned. The nature of these vesicles is uncertain; but it is not improbable they may be homologous to what have hitherto been called the *spores* of *Tubercularia vulgaris*, this latter plant being now considered to be nothing more than the mycelium of a *Sphæria* (*S. cinnabarina*), and the so-called spores to be, in fact, only conidia of that *Sphæria*. I have as yet only seen these globular vesicles in the two instances shown in fig. 5, but I have observed other branches of the mycelium which became rounded at the apex, and in which a nucleus was formed. After the formation of the nucleus a fresh germ was thrown out (see fig. 7). Something similar to this has been observed by M. Tulasne in the *Uredineæ*, in which the germ-filament has become inflated, and then thrown out a fresh shoot.*

In fig. 8 is represented a cellular body, which was attached to the mycelium by a delicate stalk, the stalk itself being attached to the side of the body. There seems no reason to doubt that this body, differing as it does from some of those shown in fig. 3, only in being of a much paler colour, represents a young state of one of those organisms. I first observed it about nine days after the commencement of germination, at which time also the germ-filaments had in places begun to form a network by a kind of conjugation, which had taken place between the germ-filaments proceeding from different sporidia.

It follows from what has been said, that if we consider the spermatia as reproductive bodies, in the proper sense of the word, as it is applied to seeds or spores, *i. e.*, as *fruit*, then *Sphæria herbarum* has four distinct sets of reproductive organs.

* See vol. ii. of the 'Annales des Sciences' for 1854.

If, on the other hand, the function of the spermatia is not *reproductive* but *sexual*, or *impregnative*, we still have three distinct forms of fruit, viz., the sporidia contained in the asci (see fig. 9),* and the two forms of conidia (figs. 3 and 5), which grow directly from the mycelium.

2. *Sphæria? complanata, Tode.*† This *Sphæria* is as common as the preceding one, growing abundantly in spring upon the dead stems of umbelliferous plants. The spermogonia, or rather spermatiferous perithecia, are shaped like a dome, with a pointed conical ostiolum. They are distinguishable from the ascigerous perithecia by their full, rounded appearance, the latter being depressed or collapsed, *affaissé*, as the French say.

It would hardly be possible in this case to prove directly that the spermogonia and perithecia proceed from the same mycelium. In the *Æcidia*, which grow upon the soft parts of plants, it is possible by maceration and careful dissection to obtain ocular demonstration of the occurrence of the spermogonia and perithecia upon the same mycelium; but this cannot be effected with the hard, dead stems of Umbellifers, and the proof of the connexion between the spermogonia and perithecia must therefore be sought for in other evidence.

Now I found both in the spermatiferous and ascigerous perithecia some peculiar-shaped organisms, the nature of which I am at a loss to conjecture. These bodies consist of a stem, crowned by three cellular, sometimes septate, prolongations, with a seta on either side. One of them is represented at fig. 11, which will give a better idea of them than any written description. But irrespective of these curious processes which, occurring as they do in both the spermatiferous and ascigerous perithecia, seem to point to a connexion between the latter, I found in one instance the spermatia and asci, contained *in the same perithecium*, a direct proof that

* The asci and sporidia of *Sphæria herbarum* vary much in size. In fig. 9 are represented two extremes. In the one the ascus is short and broad, and the sporidia fill the whole of it. In the other the ascus is much elongated, and the sporidia, which are smaller, are collected at the upper end of the ascus. I find the latter form the most frequent.

† I am doubtful whether I have named this *Sphæria* rightly. I find two plants, in which the perithecia are precisely alike, both answering the description of *Sphæria complanata*, but the sporidia are widely different. In fig. 10 I have represented an ascus, with sporidia, of the plant to which the above observations relate. The asci of the other *Sphæria* are narrower, and the sporidia are curved, acuminate at each end, triseptate, with a swelling at the second joint. The description of the sporidia of *S. complanata*, given in the Annals of Natural History under *S. modesta*, does not accord with that in the English Flora, where the sporidia are said to be *oblong-elliptic*.

both of these latter bodies are the produce of the same conceptacle or case. Can it be that the cellular processes above mentioned (such of them at least as are not septate) are young asci, to be fertilized by the action of the spermatia? This is a mere speculation, but it is not an impossibility.

The spermatia of *S. complanata* are elliptical, about 1-4300th of an inch long, with an indistinct sporidiolum at each end.

3. *Sphæria sinopica; Fries*, Elenchus Fungorum, vol. ii., p. 81. This *Sphæria*, one of the *Cæspitosæ*, grows in tufts upon a stroma which is not always perceptible, and which Fries considers to be identical with *Tubercularia sarmentorum.* If this be so, the spores of this latter fungus must be looked upon as the conidia of the *Sphæria*, in the same manner as the spores of *Tubercularia vulgaris* are considered to be the conidia of *Sphæria cinnabarina.* The sporidia of *Sphæria sinopica* are elliptical, uniseptate, and slightly constricted at the septum. They frequently have a sporidiolum in each partition. Besides these normal sporidia, I have found in many plants of *S. sinopica* an immense mass of minute bodies, which I do not hesitate to consider as spermatia. These bodies are excessively minute, elliptical or sub-cylindrical, many of them not exceeding 1-6500th of an inch in length, and endowed with molecular motion. In most of the plants which I examined, these spermatia occurred in conjunction with the regular sporidia, but some specimens contained spermatia alone. In these latter specimens the perithecia were rather of a pyriform shape, not *depressed* as is the case with the perfect perithecia of *S. sinopica.* This fact is precisely analogous to what occurs in *S. complanata*, where the perfect perithecia are, as we have seen, flattened or collapsed, whilst the spermogonia are swollen and shaped like a dome. The spermatia of *S. sinopica* appear to be born upon fine, simple, densely-crowded filaments, which line the cavity of the spermatiferous perithecia. This *Sphæria*, it will be seen, affords another instance, in which it is clear that what might be called the spermogonium is, in fact, the true thecasporous perithecium of which the spermatia are the primary produce, and the asci and sporidia a subsequent fructification, whether produced or not by the fertilizing influence of the spermatia time will probably show.*

* In the 'Annals of Natural History' for June, 1854, Messrs. Berkeley and Broome have described, as a new species, a *Sphæria* to which they have given the name of *Sphæria* (*Nectria*) *inaurata.* It is stated to have been found near Bath by Mr. Broome, and at Shooter's Hill by myself; but there has been some mistake. The *Sphæria* on holly which I found at Shooter's Hill, and of which I sent specimens to Mr. Berkeley, is certainly *Sphæria sinopica*; at least the plants which I retained have not

4. *Sphæria Cryptosporii*, n. s.—This species has not, as far as I am aware, been hitherto described, and may be thus characterized.

Obtectæ; Peritheciis sparsis vel aggregatis globosis aut sub-globosis, collo elongato corticem perforantibus; nucleo albido; ascis late obovatis, sporidiis simplicibus linearibus, utriusque obtusis plus minus arcuatis circiter ·00036 unciæ longis.

I believe this *Sphæria* to be the perfect state of *Cryptosporium vulgare*, on the evidence of the following facts. In April of this year I placed in damp moss some twigs of alder upon which *Cryptosporium vulgare* was growing; in about a month afterwards the long black ostiola of the above *Sphæria* had protruded themselves through the bark. Upon examining the fructification under the microscope, the resemblance of the sporidia of the *Sphæria* to some of the naked spores of *Cryptosporium vulgare* (viz. those which were least strongly curved) was so striking that a possible connexion between the *Sphæria* and the *Cryptosporium* naturally suggested itself. Some of the perithecia, which were in a young state, contained an immense quantity of oily matter, and small granules in a state of active motion, some densely interwoven threads attached to the walls, and a very few sporidia resembling those of *Cryptosporium vulgare*, and which had probably formed the terminal joints of the threads just mentioned.

In another of these young perithecia I observed the terminal joint of two of the threads, which had assumed the shape shown in fig. 12 (*b*, *c*). One of them contained a moniliform row of oil globules, and was evidently the earliest state of other young asci, fig. 12 (*a*), which occurred in the same perithecium. In the more advanced plants the perithecia contained perfect asci, which, with one of the escaped sporidia, are shown at fig. 13 (*a, b*). Even when the asci within the perithecia were still young, or at least not fully ripe, the ostiola were surrounded with a milky substance ejected from the perithecia, which consisted principally of free sporidia,

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the dimorphous ascigerous fructification, they have no *tails* to the sporidia, and differ in no respect from *Sphæria sinopica*. From the description of *Sphæria inaurata* it seems to be identical in its *external* characteristics with *Sphæria sinopica*, but the fructification of the former is very peculiar. It consists of two sets of asci differing in form, and containing different sporidia; the larger asci are clavate, and contain small curved sporidia not exceeding ·00015th of an inch; the smaller, cylindrical asci, contain eight elliptic uniseptate sporidia ·0005—·0006th of an inch long, furnished with a tail at either end in the form of a delicate hyaline appendage. The two sorts of asci are figured in the 'Gardeners' Chronicle' of the 22nd July, 1854, where a full description of the plant will be found.

with an occasional ascus intermixed. Again, upon taking a section of one of the plants of *Cryptosporium vulgare* which occurred upon the same twig, I found a very few asci, identical with those of the *Sphæria*, intermixed with the naked spores of the *Cryptosporium*.

One of these asci, which is in a very early stage, is shown, fig. 13 (*c*). The membrane was of extreme tenuity, and in the middle was a linear mass of granular protoplasm, partly divided in a longitudinal direction by a dark line, which, however, did not traverse the whole length of the granular matter. Another of the asci, fig. 13 (*d*), contained a much larger quantity of granular matter, still apparently in one mass, but deeply marked and furrowed. There can be no doubt that in the two asci just mentioned the sporidia were in process of formation, and that the lines and furrows pointed to the directions in which the granular mass was eventually to become separated, so as to form the eight perfect sporidia.

The above observations would be conclusive as to the identity of the *Sphæria* and the *Crytosporium*, were it not for the possibility that the sporidia, forming the milky mass around the ostiola, might have been contained in asci which had been dissolved within the perithecium, although from the young state of the included asci this is not probable; and in the case of the section of the *Cryptosporium*, inasmuch as I did not see the asci *in situ*, it is possible that the few which occurred might have been adhering to the scalpel or brush used in a previous examination, although I have no reason for supposing that such was the case.

I think it will be admitted that the above facts afford strong evidence to show that *Cryptosporium vulgare* and *Sphæria Cryptosporii* are states of one and the same plant. It is difficult to suppose that the former is the *young state* of the latter; it would rather seem that the same conceptacle has the faculty of producing both naked spores and asci, and that it depends upon circumstances, possibly atmospheric, whether the one or the other be produced. It seems to me not improbable that the spores of the *Cryptosporium* may in some instances be converted into the asci of the *Sphæria*. I have seen what seemed to be a common spore of the *Cryptosporium*, but which had a very delicate hyaline investment, and the bodies shown in fig. 13 (*c*) and (*d*) may be only more advanced steps in the process of conversion. Some objection might be raised to this view on account of the shape of the *Cryptosporium* spores, most of which are strongly curved and acuminate at either end, but on the other hand the spores vary greatly in size and shape, and some occur plentifully, which are quite undistinguishable

from the sporidia of the *Sphæria*, see fig. 13 (*b*, *f*); the former of which represents a sporidium of the *Sphæria*, the latter a spore of the *Cryptosporium*.*

Cryptosporium vulgare is a plant not unfrequently found upon beech and alder twigs, and I much hope that some reader of this paper will repeat the above observations, which may be done without difficulty or trouble. The simplest plan for keeping the bed of moss in a proper state is to fill a common flowerpot about one-third full of crocks for drainage, and to fill the rest of the pot with *damp* (not *wet*) sphagnum moss; the moss should be kept damp by occasionally putting water into the pan in which the pot stands, and not by pouring it over the top of the moss; the pot should be kept covered with a bell-glass. Many a fungus may be grown in this manner which would not have a chance of coming to maturity in such cold dry weather as we have had this spring. By a similar process I ripened two large plants of *Reticularia maxima*, which were brought to me in the early stage, of a cream-coloured mucilage.†

I think it worth while to mention as a somewhat singular circumstance, that on the same alder twigs upon which *S. Cryptosporii* was produced, there occurred another *Sphæria*, the perithecium of which was so *amalgamated* as it were with the perithecium, or stratum proliferum, of the *Cryptosporium*, as to be hardly, if at all, distinguishable from it. The sporidia of this latter *Sphæria* were quite different from those of *S. Cryptosporii*, being broadly elliptic and indistinctly triseptate, I think occasionally quadri-septate. One of the asci of this *Sphæria* is represented at fig. 14.

There are several other fungi which have afforded me materials for interesting observations, bearing upon the questions to which this paper relates. It would, however, take too much time and space to discuss them now, but they may I hope form the subject of a future communication.

* I had found *Sphæria Cryptosporii* on one previous occasion in the course of last autumn. It was then unaccompanied by the *Cryptosporium*. I am unable to determine the wood upon which it occurred, having only one small fragment.

† These plants of *Reticularia maxima* took nearly three days to come to perfection. The length of time was probably much greater than it would have been in their natural state. *Reticularia atra* passes through all its phases in about eight or ten hours.

On Ciliary Action *as the cause of the* Circulation *in the* Cells *of* Plants. By Ferguson Branson, M.D., Sheffield.

The cause of the circulation of the granules of chlorophyll in the cells of certain plants has hitherto been involved in mystery. I have spent many hours in examining the circulation in the cells of the *Anacharis alsinastrum*, the new water-weed; and in October, 1854, I first observed a distinct ciliary wave at the edge of the outermost cells. Repeated examinations have satisfied me that the rotatory movements depend upon cilia attached to the inner surface of the cell-wall. The cilia are extremely minute, and require the highest powers of the microscope, combined with very "happy" illumination, to display their waving motion. The ciliary wave can only be seen under very good daylight, or by means of the best artificial illumination. In the *Anacharis* the cells best calculated to display the ciliary wave are those at the edge of the leaflet; for here a single layer of cells exists, and no deception can occur from the movements in the cells beneath. A leaflet should be selected in which the granules are just beginning to move, or rather have not got into rapid motion; the ciliary movement is then less active, and, consequently, can be more readily seen. The microscope must be very accurately adjusted in order to define the wave, and even then the observer's patience may be severely tried before he is rewarded with a sight so interesting and remarkable. A cell in which a large number of granules are circulating should not be selected for observation; the greater the number of granules the more will the view be obstructed and confused. I have used an eighth of an inch object-glass, by Powell and Lealand, aided by their improved achromatic condenser, and a No. 2 eye-piece. A power less than this will not define the ciliary wave. The diaphragms used are numbered 4 and 5 on the condenser. A diaphragm with a central stop—absolutely necessary for resolving the more difficult Naviculæ—will not display the cilia. I am the more minute on this point, for without great attention to the manipulation the wave will not be seen. The cilia are extremely minute, probably not much larger than the dots on some of the Naviculæ, and much more difficult to illuminate satisfactorily. It may be said that cilia so minute could not draw to the side of the cell, and then impel around it the large granules of chlorophyll which float within it. Let any one place a small portion of cork or paper in the centre of a large basin of water, and when the water is perfectly at rest gently agitate it in one direction at the side of the basin, and the cork

or paper will very soon be drawn to the edge. Now the cork in this case bears about the same proportion to the basin of water which the granule of chlorophyll does to the cell in which it floats. In the latter case, however, instead of a single gentle wave at one point of the edge of the basin, we have a wave surrounding the whole cell, formed by innumerable very minute cilia; and this multiplication of minute forces produces a current of considerable velocity. Of course the current once established becomes quicker and quicker, and is helped onward by its own impetus. This exactly explains the appearance presented on the first starting—so to speak—of the circulation in a cell: a granule of chlorophyll is slowly drawn to the edge of the cell, and then slowly moves round it; another granule follows, until all are at length drawn to the edge, and pass round; the motion then becomes quicker and quicker, until it reaches the limit of its speed. But the ciliary motion is occasionally irregular—slower in some parts of the line, or perhaps interrupted altogether; and the consequence is, that the granules accumulate at the weak, or interrupted point, until the re-established ciliary wave again urges them forward. Any one accustomed to watch the circulation in plants must have frequently observed that the granules of chlorophyll become crowded together, and then slowly and singly again move onward. Ciliary action satisfactorily explains this movement. In the cells of the *Anacharis* the cilia are arranged in lines around the cell; occasionally, however, the granules of chlorophyll, instead of passing round the cell, turn off at an abrupt angle, and cross it; when this is the case a bright line may be observed on the cell wall, and along this bright line the granules pass. This line may be distinctly seen on the cell-wall before the granules are in motion, and, if accurately examined, will even then give an indication of a minute current passing along its course. This bright line is doubtless the base of a line of cilia, but the ciliary wave cannot, under these circumstances, be seen, for the cilia are not in profile. The *Anacharis* is better adapted to display the ciliary wave than the *Valisneria*. In the latter it is difficult to slice off a single layer of cells, whilst in the former Nature has prepared a single layer most suitably arranged for observation. The currents seen in the hairs of certain plants differ somewhat from those in which the granules of chlorophyll circulate; they are more minute, irregular, and weaker. Even whilst observing a hair of the Groundsel currents start into view, which a moment before were not in existence, and as rapidly pass away—others follow a more definite course, and sometimes the whole hair appears

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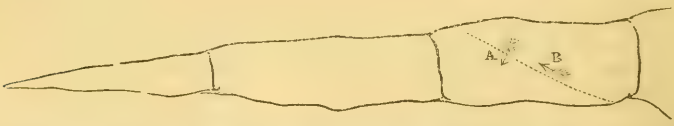
covered with a complete network of currents. I have examined many varieties of the hairs of plants, and few have been the specimens in which—in some of the hairs at least—indications of currents could not be detected; so frequently, indeed, have I found these currents, as to lead to the inference that all the hairs of plants are furnished with an apparatus adapted to the production of currents. Now this apparatus is most probably identical with that which gives rise to the circulation in the *Anacharis*, viz., minute cilia. I say most probably, for the extreme minuteness of the currents render the demonstration of cilia in many cases very difficult. In one of the hairs from the leaf of a scarlet *Pelargonium* a waving current was very evident. In the hairs of the common Primrose a ciliary wave was detected at the edge of the cells; the waving current was particularly well seen in this instance, as no granules were floating in the cell, which, when carried along in the current, interfere much with the view of ciliary action. The whole internal surface of the cells of some hairs is probably lined with a minute waving pile. At least this will account for the varied and irregular direction of the currents. In one cell, in the hair of a Polyanthus, I watched a flocculent line, or wave, passing diagonally along the whole of the cell; the current at the same time setting in the direction of the length of the wave. This is difficult to explain without a diagram.



A, arrow indicating the course of the wave across the cell. B, arrow indicating the direction of the current along which floating granules were carried.

Currents are well seen, not only in the hairs, but also in the cuticle of the leaf of the London Pride; although the ciliary wave is not well seen in this plant, in consequence of the great number of minute granules which float in the cells. The currents seen in the leaf-cells of the London Pride, and also in the leaf-cells of the Primrose, are precisely similar to those seen in their respective hairs; they are equally minute, irregular, and weak. Although the current is very distinctly seen, the motive force is not sufficiently powerful to move any granules of chlorophyll which may happen to be in the cell; occasionally, however, a granule of chlorophyll may be seen slowly moved by the current, just as the granules are

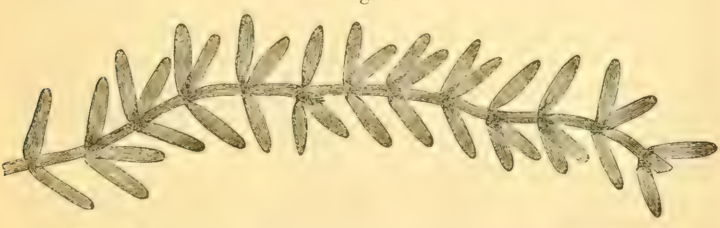
moved in the *Anacharis*, showing that the force is the same in both cases. In a hair of the Primrose I watched an octohedral crystal of oxalate of lime carried by the current several times from end to end of the cell. By the term ciliary wave it is not intended to imply that individual cilia can be seen. All that can be shown is a waving motion, such as would undoubtedly be attributed to ciliary action if seen in an animal structure. I will not at present attempt to offer any suggestion as to the use of these currents, though they must play an important part in the vegetable cell. Observations made with microscopes of high power and of recent construction are as yet too limited. Other observers will doubtless be led to investigate the subject, and the accumulation of additional facts may lead to a solution of this difficult problem.

OBSERVATIONS *on the* CIRCULATION *of the* SAP *in the* LEAF CELLS *of* ANACHARIS ALSINASTRUM. By F. H. WENHAM.

THERE is no known plant in which the sap-rotation has been discovered that displays the phenomena of the circulation more distinctly, or in such variety of detail, as the newly imported water-weed, *Anacharis Alsinastrum.* Having observed some peculiar features in this, which I have not discovered in the circulating sap of any other plant, I venture to announce them. I must, however, premise that I have not made a special study of this department of vegetable physiology, and may therefore be excused from drawing any conclusions, or for showing a defective acquaintance with technicalities;—I have simply to relate what I have seen.

Those who are not already familiar with the plant may readily recognise it by its peculiar characteristics:—Its form of growth is in long slender stems, which bear a series of *three* narrow leaves, of a pale-green colour, at intervals of

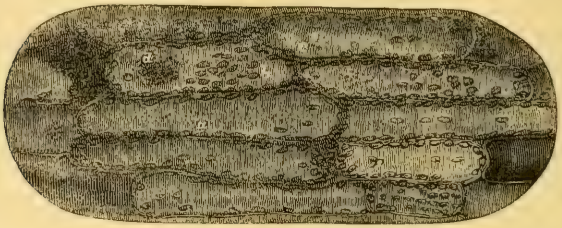
Fig. 1.



about a quarter of an inch asunder; these, when full grown, seldom exceed a length of three-eighths of an inch (see fig. 1).

The thickness of the leaf is composed of two layers of cells, irregular both in form and position, as shown in fig. 2. The

Fig. 2



margin of the leaf consists of a single layer of cells of great transparency; it is in these that the remarkable phenomena accompanying the circulatory movement are best seen. To observe this satisfactorily a good eighth is necessary, having an aperture of from 120° to 130°; if it extend beyond this the object will be less perfectly shown, on account of the close approximation of the front lens, and the difficulty of adjusting for thickness of cover. For illumination I prefer the achromatic condenser with a series of stops, and for containing the object, a compressor having thin glass both over and under the object. The best leaves for examination are those which have slightly changed colour from age; the young and vigorous specimens oftentimes displaying the circulation but very feebly.

Upon first seeing the object under these conditions, it appeared to me that there was something very remarkable in the structure of the immediate surface of the walls of those cells in which rotation could be seen: I immediately removed the microscope into direct sunlight. As thus illuminated the whole interior of the cell appeared to be lined with cilia, each developed in a most distinct manner, and altogether exhibiting the wavy undulating appearance usually caused by ciliary motion. The movement of the green chlorophyll granules also tended to favour this deception; for by the action of the supposed cilia they were occasionally collected together in a mass at one end of the cell, and the particular manner in which the preceding ones were again disentangled, one by one, at the point of least resistance, seemed to be due to the mechanical or sweeping power of the cilia.

If the existence of cilia in plants of this description could be established, it would no doubt serve to explain many obscure points in vegetable physiology; but subsequent observation has shown me that the appearance of these in the

Anacharis was a deception, caused by oblique sunlight, which though favourable for discovering the existence of minute markings is entirely unsuited for the purposes of truthful investigation. The mobile investment round the margin of the cells has a well-defined boundary: in an instance where the progressive circulation was very rapid I measured the thickness of the layer, and found it not more than 1-25,000th of an inch (in general it is rather more than this, or about 1-20,000th). Now if this should represent the extreme length of each ciliary filament, in order to possess the requisite elasticity and tenuity, the proportion of length to diameter should be at least ten to one; this would at once place the thickness of the filament beyond the limits of microscopic vision, and clearly proves that if a series of cilia really existed of these dimensions it would be impossible to see them. By examining detached portions of the cell-walls with the largest apertures and most careful illumination, I cannot discover any rugose indications in its apparently uniform outline.

I have made numerous examinations of this marvellous and beautiful object, under different circumstances and conditions, and will now describe the facts I have observed relating to its structure and vital functions. The thickness of the division between the cells is about 1-14,000th of an inch. In certain stages of disease, or decay, this sometimes becomes equally divided, showing that each cell has its own independent membrane. No particular structure can be discovered in the cell-wall: all the cells are filled with a thin fluid, and contain a number of chlorophyll granules, varying from three or four to upwards of fifty. The granules very much resemble those of the *Valisneria*, but are rather larger. Their dimensions are from 1-3000th to 1-5000th of an inch. They are somewhat irregular in shape, some being of an oval form, and others a nearly circular, flattened disc. Each spherule has a granulated appearance, arising from six or eight separate nuclei; they are rendered more apparent by a solution of ammonia, which also changes the green colour of the granule to a yellowish tinge.

The chlorophyll granules are entirely dissolved by dilute sulphuric acid. Treated with tincture of iodine they are changed to a brown colour, with a nucleus of a darker shade, and the apparent development of an external membranous envelope.

When the rotation is active the greater number of the granules travel round the margin of the cells. A few remain fixed in the centre, chiefly consisting of those whose form approaches to that of a round flattened disc.

The deportment of the granules during their passage has already been described in the Microscopical Journal for Oct. 1853, page 54, by Mr. Lawson, to whom we are indebted for the discovery of the sap-rotation in this interesting object. When the rotation is moderately active, the speed of the granules is about 1-40th of an inch per minute; a motion apparently small until magnified to 800 linear, when each granule is seen to travel round its containing cell, with sufficient rapidity, several times during one minute.

The rotation in one cell does not exert any influence upon the direction of the granules travelling in the immediately adjoining one. The motion is sometimes the same way, but quite as often in the contrary direction.

The question now is, what is the agent that gives motion to these otherwise inactive granules? I have before remarked that the whole interior of each cell is lined with an investing layer in rapid motion, of a thickness varying from 1-20,000th to 1-25,000th of an inch. This stratum I have ascertained to be entirely composed of a multitude of *active corpuscules*, differing in size from 1-60,000th to 1-90,000th of an inch. I am not quite positive about their exact dimensions, for, on account of their gelatinous nature, they do not possess a very definite outline, and are, in consequence, somewhat difficult of measurement. They are not, however, in general, much larger than I have stated.

If one of the leaves of the *Anacharis* be placed on a piece of thin glass, with a very small quantity of water, and then torn into minute fragments with two needle-points, and finally covered with another piece of thin glass, on viewing the fluid with an eighth object-glass, it will be seen that it is entirely filled with these active corpuscules, exhibiting that vigorous isochronal motion characteristic of molecular action.

A weak solution of ammonia rather increases the activity of these bodies, but dilute alcohol and acids immediately destroy the movement.

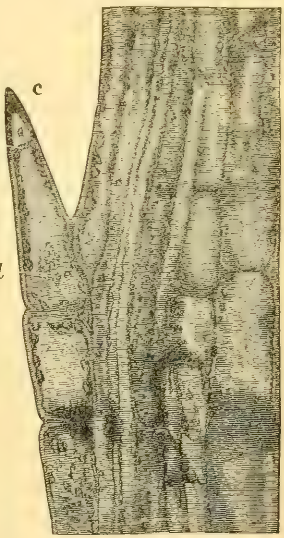
These combined corpuscules are essentially the principle of the vital movement in the plant, and also the vehicle that causes the rotation of the chlorophyll granules, which are of themselves perfectly passive, and move only in obedience to the direction and control of the corpuscular current; neither is the presence of the granules at all necessary for the excitation of the active principle of circulation, for I have repeatedly seen cells containing not a single granule, in which the circulating layer was in a rapid state of progressive motion—in fact, the presence of numerous granules rather tends to retard

the cell current than otherwise. When a stoppage occurs, the corpuscules of the circulating layer become piled against the back of the last granule; in some instances almost to overflowing; but the disentanglement is generally effected by the *tractive* influence of the moving investment releasing the preceding granules in succession.

The chlorophyll granules do not appear to possess any affinity for the active investment; they seem to be attached to it only by simple adhesion. When a granule has been impelled against an obstacle, it is sometimes thrown out from the cell-wall, and, during the first instant of its rise, I have seen it draw up a column, or thread, of the glutinous corpuscules. If the granule becomes quite detached, it will remain stationary in its position, close to the investment, till it is forced again into the line of march by the contact or motion of succeeding ones.

The investment of active corpuscules is strongly attracted by the cell-wall, and the *progressive* activity of the one appears to be dependent upon the vital condition of the other. If the continuity of a portion of the surface of the cell-wall is impaired, the active layer will not travel over the part thus differing in substance. Fig. 3 represents one of the hollow spines, or hairs, at the margin of the leaf; in these the granules are sometimes seen in active motion. When they arrive near the apex, where the cell-wall is indurated, shown by a brown discoloration, indicating a loss of vitality, they are invariably carried across the circulating layer, taking a short cut over, as at *b* in the figure. A few stray granules are sometimes thrown into the dark-coloured hollow end of the hair, but these are motionless.

Fig. 3.



Although there is undoubtedly a principle of attraction existing between the active investment and the cell-wall, yet I am led to conclude that there is nothing peculiar in the structure of the surface of the latter to determine the *direction of rotation* of the travelling current. When a plant of the *Anacharis* has been kept in a cold, dark place for one or two days, usually

not a symptom of circulation can be discovered: if a leaf suitable for examination be now viewed under an eighth, selecting the more transparent single thickness of cells at the margin of the leaf, it will sometimes be found that the layer of active corpuscules has collected, or run together, on the cell-wall into one, or sometimes two heaps or mounds, being in a torpid and quiescent state. After having carefully adjusted the object-glass, if the achromatic condenser be focussed on one of these heaps, a bright sky being used for the source of illumination, the slight degree of heat thus obtained is sufficient to call into existence the dormant vitality of the active corpuscules. At first, a few atoms on the summit of the mound appear to be loosened, exhibiting their peculiar tremulous motion; next, a few will start off and take the lead, generally across the cell, the movement of vibration being apparently converted into one of direct progression; immediately, a single file of particles will follow in rapid succession, in a wavering direction from side to side, much resembling a torrent of bubbles arising from a spherule, or small shot, at the bottom of a glass vessel of water, at the commencement of ebullition. Sometimes another line of particles will start off in a different quarter, and, as the heap of corpuscules becomes more fluid and melts down, a very singular commotion takes place; currents are seen traversing the cell all ways, without apparent rule or order, and two are sometimes seen travelling on the *same* side of the cell-wall *in opposite directions:* at last, the united numbers and strength of one current will gain the mastery, and determine the ultimate direction of rotation, which will then go on steadily for hours, the chlorophyll granules being duly arranged, and performing their traverse in proper form.

So far as I have ascertained, heat seems to be the best excitant of the circulatory movement. It is slightly accelerated by the transmission of an electric current; but this effect may also be due to the creation of a rise of temperature. The leaf of the *Anacharis* is very sensitive to the application of external reagents; weak alcohol, ammonia, or acids, instantly destroy the motion of the sap-current.

There is yet another collection of bodies found in all the various forms of cell composing the leaf of the *Anacharis*;* they are oblong spicular-looking particles, of a light-brown colour, having an average length of 1-11,000th of an inch; they mostly congregate together in the most vacant part of the cell, either at the centre or one end, and exhibit that brisk

* Seen also in the *Valisneria.*

vibratory motion peculiar to molecular action. This also occurs when there is no symptom of rotation in the cells which they occupy, and in instances where the rest of the cell contents appears to be dead. They are quite independent of the active investment, and are oftentimes so numerous as to be tangled together in a mass, forming a kind of nucleus, which is occasionally kept in rotation by the movement of the chorophyll granules. Some cells are free from them, but frequently it is difficult to find one in which they do not exist; they are not "parasitic," but form one of the constituents of the growth of the plant.

I have now recorded my observations on this remarkable plant; though I am still of opinion, from the variety of the phenomena displayed, that a careful series of examinations will bring fresh facts to light, and that the *Anacharis* (although denounced as a "pest") may possibly prove to be one of the keys for unravelling some of the mysteries of primary vegetable organization. I have entered upon the inquiry without learning what has been done by others in this department of microscopical investigation, and therefore refrain from expressing opinions or from drawing any conclusions from the result. I only offer it as a query, with respect to the elementary principle of the circulation of the sap in plants. May not their growth and vitality depend upon what is known as "molecular action?" I make the remark, because I have observed that the sap of many different vegetable species exhibits this peculiar motion; and I would further inquire, whether the *ciliary movement* discovered in several organisms, decidedly belonging to the vegetable kingdom, may not also be a modification of molecular action, and governed by the same exciting power? For it appears to me that there are many points of analogy; and it is difficult to imagine that a single cilium, of perhaps unicellular structure, and so minute as to be almost beyond the limits of microscopic vision, should derive its vibrations from an internal mechanism. Experiment tends to prove that the acting stimulus of motion exists externally.

I have finally to remark that this is one of those comparatively-few subjects which requires the use of large apertures, and the highest powers for its investigation (I have found a twelfth extremely serviceable), combined with considerable care in the illumination; for many of the phenomena are on so minute a scale as to be classed among very difficult tests.

TRANSLATIONS.

On the Cellulose (*in Animals*) Question. By R. Virchow. Archiv. f. pathol. Anatomie, ü. Physiologie, &c., vol. viii., H. 1, p. 140.

Since my former communications respecting the substance met with in the human body resembling vegetable cellulose, I have taken much pains to ascertain more precisely its nature. In now recurring to the subject, it is not that I have been altogether successful in the inquiry, but rather because I perceive that it is becoming more and more involved in confusion. There are some even who, whether from superficiality or for other reasons, appear to regard what I have said,—as I believe with sufficient distinctness—as unsaid, and have busied themselves in associating with the amyloid bodies described by me, bodies of all kinds, only *morphologically* analogous with them. *The reaction of iodine and sulphuric acid having once been established, nothing can be described as a corpus amylaceum which does not exhibit this reaction. At most can such bodies be termed corpora amylacea spuria.*

To this class of false amyloid bodies, which have been explained as *true*, belong—

1. The *brain-sand*, noticed by Cohn (Bericht, über das Allerheiligen-Hospital zu Breslau, 1854, p. 14). Except that Busk (Quart. Jour. Mic. Sc., 1854, January, No, 6), in one instance, under particular circumstances, found in the *corpus striatum* calcareous bodies, whose external soft layer assumed a peculiar reddish-yellow colour under iodine alone, which induced him to compare it with the immature cellulose of many plants, as of *Hydrodictyon.*

2. Various *gelatinous granules*, which have of late been frequently comprehended under the ambiguous name of "colloid granules." Many of these are decidedly of an albuminous nature, as I have said before (vol. vi., p. 580). It is possible that the bodies described by Gunsberg (Zeitsch. f. Klin. Med., v., p. 297) from a colloid tumour of the abdomen belong to this class, although the description is not sufficiently clear; and in a cerebral tumour occurring at the same time, arenaceous corpuscles are described as of an amyloid nature.

3. The *concentric epidermis globules* (globes épidermiques), which are met with most abundantly in cancroid tumours,

and which Gunsberg places with the *corpora amylacea.* To this category also belong, as I first stated (Arch., vol. iii., p. 222), the concentric bodies of the thymus-gland, of which Funke (Wagner's Physiol., 4th ed., 1854, p. 127), supposes that they are identical with the *corpora amylacea* of the brain. I have expressly stated (vol. vi., p. 138), that they do *not* exhibit the peculiar reaction with iodine and sulphuric acid. The same may be said of the so-termed colloid bodies of the *hypophysis cerebri.*

4. The so-termed Hassallian corpuscles in coagulated blood, but which should properly be named after Gulliver, since they had previously been described and figured by him in his translation of Gerber.

5. The *medullary matter* described by me (vol. vi., p. 562), and identified by Henle with the Hassallian corpuscles, notwithstanding that its analogy with the nerve-medulla had not escaped his notice, and which is placed by Meckel under his "lardaceous substance" (Speckstoff), although it is a normal constituent of most tissues. I had already stated that this substance does not exhibit the peculiar reaction with iodine and sulphuric acid, that it is soluble in hot alcohol, in ether, and other substances, in which the *corpora amylacea* are insoluble, and also that it resists concentrated acids and alkalies, which at once destroy the *corpora amylacea.* In short, this medullary matter (Markstoff) has nothing in common with the *corpora amylacea.*

6. *Leucin-granules*, which are so readily separated particularly in extract of milk, and which have also been described by Meckel as a kind of fat, and placed under the lardaceous substances. These bodies also, do not exhibit the reaction with iodine and sulphuric acid.

Among all animal substances there is but one, so far as our present knowledge extends, which can be brought into question, and this is *cholesterin.* The great difference which exists between cholesterin and the *corpora amylacea*, I have already (vol. vi., p. 420) pointed out in a cursory manner. It will be sufficient, here, to remark that *the cellulose-like or amyloid substance, whenever it is met with, exhibits changes under iodine alone without any addition;* thus the *corpora amylacea* of the nerve substance exhibit a bluish, and those of the spleen, liver, and kidney, a yellowish-red colour. Were this not the case, it would have been quite inconceivable how Donders and Busk should ever have thought of such a thing, as at once to declare them to be of the nature of starch. No sort of cholesterin upon the simple application of iodine presents any change of the kind, and

still less is it witnessed in situations where cholesterin in the combined state exists abundantly; as, for instance, in the nerves and in the spleen, of which I have shown that when it has not undergone the amyloid change, still it contains a very large amount of cholesterin (vol. vi., pp. 425, 565). On the other hand I would again remark, that *sulphuric acid by itself* changes cholesterin-crystals into brown or brownish-red drops (vol. vi., p. 420, *vid.;* also Würzb. Verh., B. i., p. 314), whilst the *corpora amylacea* are destroyed without any change of colour.

Busk, in his researches, besides iodine with sulphuric acid, also employed Schultze's reagent,—chloride of zinc and iodine,—and obtained also by its means the blue reaction. I can confirm this as regards the brain, as well as with respect to the waxy degeneration of the spleen, liver, and kidney. This reagent even is to be preferred, from its greater convenience of application, to the iodo-sulphuric acid, only it must be very carefully prepared. At first I had hoped that it would afford a new test by which to distinguish cholesterin, but it was soon apparent that it also induced the most beautiful blue colour with that substance, although very slowly. At the same time I perceive, with much astonishment, that in England many conceive that the amylaceous nature of the bodies is proved by this reaction. This is altogether erroneous, for it is precisely this which is to be regarded as especially characteristic of cellulose.

In the impossibility of completely isolating the substance in question, I have repeatedly sought to produce its characteristic decompositions. My endeavour to change it into sugar, by means of sulphuric acid failed (vol. vi., p. 426). I then experimented with saliva, and of course with *saliva* which was proved to be capable of readily decomposing vegetable starch. But these experiments also afforded no satisfactory result, either with normal saliva or with the secretion of a person under mercurial salivation, which possessed very energetic decomposing properties. Another series of experiments appeared to afford more favourable results; but I was unable to arrive at any definite conclusion, owing to the circumstance that, latterly, fresh materials were wanting. In any case the question remains in this state, viz.:—that of all known substances none appears to be so closely allied to these bodies as are starch and cellulose.

In respect to the situation in which the degeneration may be demonstrated with certainty, they are as follows:—

1. The *nervous system.* Besides the situation before noticed may be mentioned the *ligamentum spirale cochleæ* (Wurzb. Ver-

hand., Bd. V., p. 18), and numerous points in the atrophied substance of the brain and spinal cord. I have myself repeatedly found them in astonishing quantity in the gelatinous and cellular softening of the brain, and particularly of the spinal cord. Busk found them, in one case, throughout nearly the whole brain. Willigk (Prager Vierteljahrsch. 1854, Bd. IV., p. 93) discovered them in cicatriform spots in the brain; and Rokitansky (Sitz. Ber. der Wiener Akad, 1854, Mai. Bd. XIII., p. 122), in various parts in a state of atrophy, particularly in the brain. Like Busk I have also seen them in the choroid plexus, although I am not quite sure whether they may not have been accidentally introduced.

2. The *spleen*. In this organ the change exists both in the cells of the follicles and of the pulp. The arteries, as has been stated before by Meckel, exhibit the degeneration in their thickened walls throughout all the coats, and, in particular, there is no doubt that the annular fibrous coat also participates in it. Sanders (Monthly Journal, 1854, Nov., p. 468) rightly remarks that the *trabeculæ* likewise are changed; I have seen them thickened and rendered blue throughout by the action of reagents. If the deposit is not quite pure, the colour is more of a violet tint, or perhaps of green or greenish blue.

3. The *liver*. In the true waxy degeneration it is chiefly the hepatic cells which undergo the change, although it sometimes happens that the interstitial connective tissue as well is implicated in it.

4. The *kidneys*. In these organs the amyloid condition is of the most frequent occurrence. The change commencing most usually in the Malpighian coils and in the afferent arteries, which are enormously thickened and have their walls infiltrated throughout. Next to these the connective tissue, surrounding the papillary *tubuli uriniferi*, is chiefly affected; far more rarely the portions seated higher up.

Further investigations will show whether a simple infiltration exists in these cases, or a direct degeneration. The case related by Stratford (Quarterly Journal Mic. Sci., 1854, p. 168) of an epileptic patient, in whom *corpora amylacea* are said to have existed in the blood, is not so certain that the matter can be regarded as decided by it. In any case, in most organs we have to do with an indubitable change in the structural elements; and should my original view be farther confirmed, this change might briefly be described as a *lignification* of them.

It is of especial interest to consider the finer varieties of this substance in connexion with the corresponding vegetable

matters. The *corpora amylacea* of the nervous centres, both morphologically and chemically, approach the nearest to the *amylox-granules* of plants. They have the same concentrically-striated structure, the comparatively strongly-reflecting surface, the bluish colour, upon the simple application of iodine, and lastly, their swelling in hot, and their ultimate solution, although with chemical change, in boiling water. Busk even says, what Donders and myself have been unable to perceive, that some of the smaller *corpora amylacea* exhibit, in polarized light, a sharply-defined dark cross, the lines forming which decussate in the centre of the granule at an angle of 45°, though it must be allowed that most of them exhibit only a single dark line. The same observer also believes that in one case he perceived minute particles of the amyloid substance enclosed in cells, whose cavity they only partly occupied.

Widely different from the above is the amyloid degeneration of the vessels, of the connective tissue, and of the cells in the spleen, liver and kidney. In these situations I have never obtained a blue, nor even a bluish colour, by the addition of iodine alone; on the contrary, the peculiar yellowish-red is exhibited, which has from the first surprised me (vol. vi., p. 269), and which Meckel has since described as "iodine-red," and proposed as a characteristic of his lardaceous substance. But at the same time care must be taken with respect to this, since, especially all parts containing blood, often assume a very similar appearance. At present it appears to me that we are in no case justified in admitting the existence of an amyloid substance, where a violet-blue or bluish-green colour is not produced upon the subsequent addition of sulphuric acid or of chloride of zinc. But in all such cases it is advisable by the simple addition of concentrated sulphuric acid, to satisfy oneself that similar colours are not produced by that reagent, as may very well be the case, especially in a series of animal colouring matters.

Whether the yellowish-red, or iodine-red appearance of the parts indicate any specific substance, is still to be shown. Busk seems inclined to compare with it a kind of immature cellulose, such as is said to occur in the lower plants. In any case, however, the deposition of the substance presents a close resemblance to true lignification—the formation of cellulose in plants. But in the vegetable kingdom, as is well known, the most numerous combinations of cellulose with nitrogenous substances are met with, so that, as Mulder in particular has shown, on the addition of iodine with sulphuric acid all sorts of impure colours are presented, constituted of a mixture of

blue and red, or of brown and yellow. A similar play of colour may be witnessed particularly in the spleen, and especially in the amyloid procured from the pulp and from the follicles, whilst nowhere do the blue and bluish-red colours at once appear so distinctly as in the Malpighian coils and the afferent arteries of the renal parenchyma. It appears, therefore, scarcely to admit of a doubt, *that sometimes sooner, sometimes later, the albuminous substance of the tissue disappears and is replaced by the amyloid.*

In those cases, in which the substance differs still more widely from starch, and more close approaches cellulose, the organs affected exhibit the peculiarly pale, transparent, reddish or yellowish, or even brownish aspect, together with the characteristic, as it were, œdematous consistence, which, as I conceive (vol. vi., p. 426), should be described as "waxy," and not as lardaceous. I see with pleasure that the same idea, independently of me, has been adopted in Edinburgh, and the process been at once described as "waxy degeneration" (Monthly Journal, 1854, February and March). In the majority of cases the indurated organs are at the same time enlarged, so that no doubt can be entertained that new matter must have been taken up.

The coexistence of amyloid disease in the liver, spleen, and kidneys, which has been so often observed, though not so frequently as many believe, of course leads to the supposition of the existence of a common cause—of a *constitutional disturbance.* A humoral pathologist would naturally suppose a corresponding crasis. But a more cautious observer would be satisfied with saying, as I have done in my former communication on the subject of the "waxy spleen," that the common factor is a cachectic condition, whose more special nature remains to be elucidated.

On the Action *of a* Concentrated Solution *of* Urea *upon the* Blood-Cells. By A. Kölliker. (Zeitsch. f. Wiss. Zool., vol. vii., p. 183.)

In the prosecution of a series of researches, respecting the influence of various reagents upon the spermatic filaments, I have almost always employed the blood-cells as a test of the degree of concentration of the fluids experimented with. I was thus led to observe, in the Frog, a remarkable change produced in the blood-cells by a concentrated solution of urea (30 per cent.). The blood-cells gradually acquired an irregular, jagged outline, and were rapidly transformed into the

most beautiful stellate cells, usually having 3—6 tolerably long and somewhat clavate processes, so as to be brought to resemble very closely the irregularly-stellate pigment-cells of the *lamina fusca* of the sclerotic. This elegant form, however, was not long retained; for the processes now began speedily to become melted down, sometimes disappearing by a gradual process of fusion commencing at the border of the cell, and occasionally in detaching larger or smaller droplets, which immediately became pale and disappeared. Thus, at last, the nuclear part of the cell only remained as a minute, round, dark-red, brilliant globule, which, ultimately, also lost its colour and disappeared up to the *nucleus* without leaving a trace.

In order to ascertain the causes of these extraordinary changes in the blood-cells, I began now to try the effect of weaker solutions of *urea*. These experiments showed, that solutions containing 15 per cent. produced the same changes as those above described, and this was the case also, though more slowly, with solutions containing 12 per cent., or having a specific gravity of about 1·043. In solutions of 1·026 sp. gr., the cells remained almost without change, whilst in others still more diluted, down to a sp. gr. of 1·004, they were rendered spherical and pale, with distinctly-visible *nuclei*, just as they appear upon the first addition of water. These phenomena, as well as the considerations which are opposed to the assumption of a chemical influence being exercised by an indifferent substance, such as *urea*, upon the blood-corpuscles, induced me to try the effect of other concentrated solutions upon the blood-cells of the Frog, whence it appeared that in solutions containing 30 per cent. of "sugar of milk," numerous blood-cells were rendered so pale, that nothing remained visible except the *nuclei*. The same thing takes place in all the cells in a concentrated solution of *glycerin*, except, that in this instance, many of the *nuclei* exhibit a very delicate border due to the cell membrane. A similar effect follows the application of mucilage of quince seeds. But in none of these solutions did the blood-cells assume the stellate form, nor exhibit the extraordinary fusion, and breaking up into spherical drops, which is manifested in solutions of *urea;* upon which, however, the less stress, perhaps, should be placed, since human blood-cells, in a solution of urea containing 30 per cent. simply diminish in size, become rounded and lose their colour, without previously exhibiting any other phenomenon. Of salts I have hitherto only tried solutions of common salt and of acetate of soda (Na O $\bar{A}$). When concentrated solutions of these salts are mixed with frog's blood, and the

mixture is left to itself for a few minutes, most of the corpuscles lose their colour entirely, scarcely anything remaining visible except the *nuclei*. If the changes are followed more closely, the corpuscles will be seen at first to become wrinkled, in which condition also many remain for a long time; but this is succeeded by a stage, in which they become smaller and rounded, and perhaps also throw out a few rounded protrusions, until at last they are rendered quite pale. On the prolonged action of common salt, the corpuscles may often be seen surrounded with a complete cloud of liberated particles of *hæmatin*, and it would even seem that the cells frequently disappear altogether under the energetic influence of the concentrated solution.

From the above it is allowable to regard the whole phenomenon as one of a physical nature, and to assume that, as dilute solutions remove the colour of the blood-corpuscles by endosmosis, so do concentrated solutions produce the same effect by causing an excessive exosmotic current from the blood-cells into the surrounding fluid. The very energetic action of *urea*, may perhaps be explained by the high value of the endosmotic equivalent of that substance, with respect to which I hope at some future time to be able to communicate more precise observations.

NOTICE *respecting the* OCCURRENCE *of* LYMPH-CORPUSCLES *in the commencements of the* LYMPHATIC VESSELS. By A. KÖLLIKER. (Zeitsch. f. Wiss. Zool., vol. vii., p. 182.)

THE recent researches of Virchow on the one hand, and of Brücke, Donders, and myself on the other, have shown that the lymphatic glands are the principal seat of origin of the cellæform elements of the chyle. The further question arises, as to whether lymph-cells are formed in other situations besides those organs, and particularly, whether the independent formation of such cells, in the commencement of the lacteals, which has recently been almost universally assumed, be really deducible from well-ascertained facts. This question is of the greater interest, that the formation of lymph-cells in the commencement of lymphatics has hitherto been regarded as one of the most certain instances of the formation of cells around isolated *nuclei* contained in a fluid, whilst the more recent results of histological inquiries have tended more and more to limit the occurrence of a free cell-formation independent of pre-existing cells. Consideration of the foregoing facts, would certainly, at first sight, appear to render the

question now in discussion superfluous, inasmuch as it has long been proved that the lacteals of the small intestine, even at their commencement between the intestine and the mesenteric glands, contain lymph-corpuscles; but here the possibility arises, that the cells may be derived from the Peyerian and solitary follicles, whose connexion with the lacteals is asserted by Brücke, and which on this account have been regarded as a kind of lymphatic glands. In this state of things, it is above all necessary to investigate the conditions under which, and the situations in which, the lymphatics contain cellæform elements previously to their reaching the lymphatic glands, and where not; an investigation which, when carried out sufficiently, is more difficult than it appears at first sight. Although I have had neither opportunity nor leisure of instituting detailed researches on this subject, still I am in a condition to communicate some facts, which may serve as an introduction to further inquiries.

In a large Dog, which had been copiously fed a few hours before death, and in which all the lymphatics of the abdominal organs were distended, H. Müller and I found, in all the lacteals proceeding from the Peyerian glands, (which in such cases are always enlarged,) in every preparation, a considerable amount of colourless cells. The chyle from the other vessels of the small intestine, however, also contained cells, but these were in general less abundant, though in one case likewise the number was not inconsiderable. In the same way also the lymphatics arising from the large intestine contained a certain number of cells in the pale-coloured lymph. On the other hand, we were unable to discover a trace of cellæform elements in the lymph taken from the much-distended vessels of the liver.

Upon the supposition, therefore, that the solitary follicles of the small and large intestine communicate with lymphatic vessels, these facts would appear to correspond with the hypothesis, that the lymphatic glands and the analogous follicles of the intestines are the only sites of formation of the lymph-cells.

On the other hand, again, I invariably found in the large lymphatics of the spermatic cord of the Bull, close to the epididymis, in several very carefully-examined cases, a certain, though it is true but small, number of cells, which were indistinguishable from lymph-corpuscles.

Further investigation, for which I would recommend the lymphatic vessels on the exterior of the gastric mucous membrane of the Pig, and those of the uterus and liver in the large mammalia, will show in what cases lymph-cells exist

in lymphatics, which have no connexion of any kind with glandular organs. Should it thus appear, of which I can scarcely doubt, that the occurrence of these corpuscles, observed by me in the lymphatics of the testis, is a frequent event, the origin of these lymph-cells will have to be traced further, and above all, it will be requisite to consider whether, perhaps, the epithelial cells of the smaller lymphatics may not participate in this cell-formation more than we have hitherto been inclined to believe.

On the INFLUENCE *of* CAUSTIC ALKALIES *upon the* MOTIONS *of the* SPERMATIC FILAMENTS. By A. KÖLLIKER. (Siebold and Köllik. Zeitsch. f. w. Zool., vol. vii., p. 181, March 26, 1855.)

SETTING out with the well-known observation of Virchow (Virch. Archiv., vol. vi., p. 133, 1853; Quart. Journ. Mic. Sci., vol. ii., p. 108), with respect to the action of caustic potass and soda on the *cilia*, I have in the last winter investigated their action upon the spermatic filaments. To my agreeable surprise a perfect correspondence was exhibited between these two motile bodies, except that I noticed an influence from ammonia upon the spermatic filaments, which had not been observed by Virchow in the cilia. In order to observe the action of caustic alkalies upon the spermatic filaments, the best mode of proceeding is to allow them to become perfectly quiescent in a dilute solution of sugar or of albumen, and afterwards to introduce the caustic in small quantity beneath the covering glass. It will then be seen wherever the potass or soda reaches that the mass is again put into the most lively motion, fully as active as that of the perfectly-fresh spermatozoids; but after a short time ($\frac{1}{2}$—1—2 minutes) a total quiescence takes place, from which the spermatic filaments cannot in any way be again roused. This phenomenon is best witnessed on the application of a solution containing from 1 to 5 parts in 100 of caustic soda or potass. In stronger solutions it undoubtedly takes place, but in this case the movement is soon over, nor does it occur in all the filaments, many of which, and especially those which first come into contact with the stream, exhibit, instead of active vibratile and locomotive movements, only a few rotations on the axis, and then become quiescent in the extended posture. Concentrated solutions of caustic alkalies, containing from 10 to 50 in 100, also produce the phenomena of revivification in a mass of quiescent spermatic filaments, and

in a well-marked manner, but in this case care is still more requisite than with more dilute solutions.

The above phenomenon is witnessed not only in the *Mammalia* in which I first observed it, but also in the *Amphibia*, except that in the latter (Frog) far more dilute solutions of caustic alkalies are required to produce it, the spermatic filaments of these animals being much more readily destroyed than those of the Mammalia. As respects the Birds and Fishes, my observations in these classes are not concluded.

When the action of caustic alkalies upon the spermatic filaments is observed farther, it is obvious that they are powerful excitants, not only in concentrated solutions, but that they also exert an influence in dilute solutions also. If a solution of sugar, which does not affect the movements of the spermatic filaments, be mixed with a small quantity of caustic potass, so as to make a solution containing 1-1000 to 1-5000 of the alkali, it will be seen that a fluid of this kind not only maintains the motions of the filaments for hours together, but that it renders them even more lively than in the pure syrup itself, so that it would seem as if very weak alkaline fluids of a certain strength are the most favourable to the movement of the spermatic filaments.

On the RESTORATION *of the* MOTIONS *of the* SPERMATOZOIDS *of the* MAMMALIA. By MM. MOLESCHOTT and J. C. RICCHETTI. (Comptes rendus, No. 13, Mars 26, 1855.)

THE author's researches were made on the spermatozoids of the Bull, taken in each experiment from the epididymis. These spermatozoids have a lynx-shaped head, the depression in which is small and situated towards the inferior third, and a very long tail, furnished with a minute appendicular nodosity, which is soluble in the alkalies, and is usually placed in the middle of the filament, though in some individuals it is situated nearer to the head.

When the *testes* have been procured from an animal recently killed, the vitreous humour, diluted with three parts of water and filtered, is very appropriate for the observation of the movements of the spermatozoids; but this fluid is no longer sufficient when the *testes* have been kept for one or several days. In order, then, to revive the spermatozoids, we are acquainted with nothing which succeeds better than solutions of common carbonate or phosphate of soda, containing 5-100th of the salt. By this means, even after the lapse of two days, all the characteristic movements of the spermatozoids may

be excited. At first, only a few exhibit trembling vibrations, but which are soon communicated to others, and in two or three minutes the whole are in motion as actively as in the recent secretion. We have several times succeeded in reanimating these motions of the spermatozoids, in the secretion which had been retained in the epididymis three or four days after the death of the animal, at a temperature varying from 5° to 20° Cent. If, instead of solutions of the above strength, more concentrated ones are employed, the action is commonly slower, weaker, and, above all, less general; nevertheless we have occasionally seen movements produced quite as rapid, and also quite as general by means of a solution, containing 1-10th of the salt; a solution containing 1-100th of the salt is usually inert.

Chloride of sodium, is less efficient than the phosphate or the carbonate of soda, inasmuch as its action is only very feeble beyond 48 hours after the death of the animal. But it is extremely remarkable, that a solution containing not more than 1-100th of common salt produces the greatest effect, whilst solutions containing 5, 10, and 26·4 per cent. have none at all, and even solutions of 3 to 4 per cent. are far less active than those with 1 per cent. The latter surpasses in efficiency the solution of sulphate of soda, which, like the carbonate and phosphate, ought to be of the strength of 5-100th. Solutions containing 1 to 10 parts of the sulphate in 100 have a feeble action, and the concentrated solution produces none at all. Ordinarily the solution of sulphate of soda, containing 5 parts in 100, is less certain in its effects and less active and durable than the carbonate, phosphate, and chloride, particularly if the secretion is not recent.

As for the salts of potass, we have compared the carbonate in a solution containing 5 in 100, and the chloride in one containing 1 in 100. Their action is less constant, slower, less lively and less general than that of the salts of soda.

What has been said of the semen of the Bull does not apply to that of the Frog (*Rana esculenta*). According to our observations, common salt retards the movements of the spermatozoid of the latter animal; the phosphate and the carbonate cause them to cease altogether. The spermatozoid of the Frog coil up in solutions of the same salts, and at the same degree of concentration, as revive those of the Bull with the greatest energy. This difference recalls a fact observed by M. Moleschott, that the blood-corpuscles of birds (Fowls, Pigeons) are less corrugated under the action of saline solutions than are those of the Mammalia and of the Frog.

On the Vitality *and* Development *of the* Spermatic Filaments. By A. Kölliker. (From the Verhand. d. phys. med. Gesellsch. in Würzb. Bd. VI., 1855.)

Referring to a former communication (*vide* p. 293), containing the observation, that caustic alkalies are powerful excitants of the spermatic filaments, the author believes that he has now arrived at certain results, of which the present paper gives a preliminary account, the more detailed exposition of his inquiries being reserved for a future occasion.

The results which he has obtained, with respect to the motile phenomena of the spermatic filaments, are embraced in the following propositions, which have reference to the Mammalia.

1. In *pure semen*, taken from the epidermis and *vas deferens*, motile spermatic filaments exist in very great abundance.

2. In *water and aqueous solutions of all innocuous, indifferent substances and salts*, the motion of the filaments ceases, and they form loops.

3. These filaments, thus furnished with loops, *are not dead*, as has hitherto been generally believed; for, on the contrary, they revive completely upon the *subsequent addition of concentrated solutions* of innocuous, indifferent substances (sugar, albumen, urea), and of salts.

4. In all *animal fluids*, when considerably concentrated, or highly saline, which are not too acid nor too alkaline, nor too viscid, the motions of the spermatic filaments are unimpaired; this is the case, for instance, in blood, lymph, alkaline or neutral urine, alkaline milk, thin mucus, thick bile, the vitreous humour,—but not in saliva, acid, or strongly-ammoniacal urine, acid milk or mucus, the gastric juice, thin bile, and thick *mucus*. When the proper degree of concentration of the latter fluids is successfully attained, and their reaction is rendered neutral, they are innocuous.

5. In all *solutions of indifferent organic substances moderately concentrated* the filaments move with perfect facility—thus in all kinds of syrup, in albumen, urea, glycerin, salicin, amygdalin. More concentrated solutions of these substances cause the motion to cease, but it is restored upon their subsequent dilution with water. Too dilute solutions act in the same way as water (*vide* 2 and 3).

6. *Certain solutions*, as they are termed, of indifferent organic substances act like water, however much they may be concentrated, such as solutions of gum arabic, vegetable mucus (gum tragacanth, mucilage of quince-seeds), and of dextrin. Concentrated solutions of other substances, in this case also, restore the motions.

7. Many *organic substances* cause the motions of the filaments to cease, owing to their chemical action upon them, such as alcohol, creosote, tannin, and ether; others owing to their mechanical effects, as most oils. Narcotics, in certain degrees of concentration, are not injurious.

8. Metallic salts are injurious, even in extremely dilute solutions; such, for instance, as a solution containing $\frac{1}{10000}$ of corrosive sublimate.

9. Most of the *alkaline* and *earthy* salts are innocuous in certain degrees of concentration, which in some is greater and in some less; so little hurtful, in fact, are they, that the filaments may be kept alive in them for

from one to four hours. Among these may be enumerated solutions of— common salt; chloride of potassium; sal ammoniac; nitrate of soda; nitrate of potass, containing 1 part to 100: moreover, solutions containing from 5 to 10 parts in 100 of phosphate of soda; sulphate of soda; sulphate of magnesia; chloride of barium. As regards some of these salts, the fact had been previously noticed by older writers, and more recently by Quatrefages, Newport, and Ankermann. Solutions unduly diluted have the same effect as water, and cause the formation of loops, *but the filaments are revived upon the addition of a concentrated solution of the same salts and of indifferent substances* (sugar, urea, &c.). Stronger saline solutions than are required, also interfere with the motions; but, in this case likewise, the filaments are capable of revival upon the addition of water. These salts can scarcely be regarded properly as revivifiers, as was asserted not long since by Moleschott and Ricchetti (*vide* p. 294), for filaments which have become quiescent in indifferent substances, as sugar, for instance, are not revivified again by them; and their action is widely different from that of the real excitants—the caustic alkalies. It cannot be denied that their influence is very favourable, and that (but perhaps owing only to their rapid diffusion in the water) they produce motion in a seminal mass more rapidly than other less diffusible substances, such as sugar and albumen; on which account the above-named authors ascribe revivifying properties to them—a fact which, before them, had been made known, as regards common salt, by Quatrefages, and by Newport, for carbonate of soda and potass; which latter salts, moreover, in my experiments, caused the motion to cease in 10′ or 15′, almost like the caustic alkalies.

10. *Acids*, even in very small quantity, are injurious; such as hydrochloric acid, in the proportion of $\frac{1}{7500}$.

11. *Caustic alkalies* (soda, potass, and ammonia, not lime and barytes), in all degrees of concentration, from $\frac{1}{31}$ to $\frac{6}{10}$ are special *excitants* of the spermatic filaments. Whether the latter have become quiescent spontaneously, as in old semen, or have ceased to move in indifferent solutions, the above substances recall the most active movements which are not distinguishable from the vital. But these motions cease after two or three minutes, and from this quiescence the filaments cannot be roused by any means. When mixed with indifferent substances in small proportions (from $\frac{1}{1000}$ to $\frac{1}{500}$), as, for instance, in syrup, the caustic alkalies afford a means by which the motions of the spermatic filaments may be maintained for a long time.

12. *Semen dried* in indifferent substances, and in saline solutions, may, in certain cases, have its motion restored by dilution with the same fluid, or with water.

So much, as regards the Mammalia, with which, so far as the author has had an opportunity of observing, the Birds correspond in all essential particulars. In the Amphibia, as, for instance, in the Frog, a difference was so far observable that the spermatic filaments, owing to their chemical constitution, required less concentrated solutions, in order to exhibit their natural motion On this account water and aqueous solutions have very slightly-deleterious effects on them; and greater dilution is requisite in the saline solutions, in order to exhibit the movements, than in the Mammalia. That is to say, one-half per cent. solutions of common salt; chloride

of potassium; chloride of ammonium; nitrate of potass; nitrate of soda; carbonate of soda; and solutions containing $\frac{1}{100}$th of phosphate of soda; sulphate of soda; sulphate of magnesia; muriate of lime; muriate of barytes, &c. All the other conditions are alike: thus, in particular, the revivification from concentrated saline solutions, except that the alkalies act as excitants only in very weak solutions, and are destructive in stronger.

The spermatic filaments of Fish, in their behaviour towards water, correspond more with those of the Amphibia, but they are by no means so long-lived. They are distinguished also from those of the Amphibia, and of all other vertebrate animals, by the greater delicacy of their structure, and by the difficulty which exists in the finding of media favourable to their motion. In general the same degree of concentration in the solutions should be employed with them as with the spermatic filaments of the Frog, except that it seems there are but few substances, such as phosphate of soda in the proportion of 1 per cent., and of sulphate of magnesia of the same strength, which are altogether favourable to them; but in these media I have seen them in active motion for from six to twelve hours; and such solutions are perhaps adapted for the prolonged maintenance in an active state of the seminal fluid of Fish. *The revivification after the action of water and of too concentrated solutions takes place in them in the same way as in the spermatic filaments of the Mammalia.* The caustic alkalies also act upon them as excitants, though only in dilute solutions of $\frac{1}{3}$ to $\frac{1}{4}$ per cent., for in stronger the filaments are immediately destroyed.

When these facts are carefully considered, it is obvious that it is impossible, with Ankermann, to regard *the motions of the spermatic filaments as the effect simply of endosmosis.* I consider that they are induced by molecular changes in the interior of the filaments, which, though unknown, may at present be compared with those in the muscular fibres, and still more aptly to the ciliary organs of the Infusoria, and to cilia in general. Should any one be inclined to the opinion, that the revivification of filaments which have been treated with water, by the application of concentrated solutions, as of sugar, salts, albumen, &c., as well as the restoration of motion by means of water, after treatment with too concentrated saline solutions, are circumstances in favour of Ankermann's views, I would remark, that *the Infusoria and cilia also behave in the same way towards saline and other solutions.*

The *Opalinæ*—minute Infusoria from the rectum of the Frog, and the cilia of the Frog's tongue—move in a solution of common salt of 1 per cent., and of phosphate of soda of the

strength of from 5 to 10 per cent. In a solution of salt of 5 per cent., and of sugar of from 10 to 15 per cent., they shrink up and become quiescent, though reviving upon the addition of water: I have even succeeded in reviving the *Opalinæ*, after they had been treated with a solution of common salt, in the proportion of $\frac{1}{10}$th.

With respect to the *development* of the spermatic filaments, I will here say only this much, that, from my latest observations, they are not developed *in* the *nuclei* of the spermatic cells and cysts, but *out* of them. These *nuclei*, which occur either singly in small cells, or in numbers together, *free* in larger cells and cysts, become elongated, and push out from one end a filamentary process, whilst the principal mass constitutes the body of the filament. The spermatic filaments are at first coiled up in the cells and cysts, and are afterwards liberated by the perforation of these receptacles, in doing which they frequently carry with them portions of the walls, forming the appendages and hood-like cauls which have been already pointed out by other observers.

NOTES AND CORRESPONDENCE.

Reply to some Remarks by F. H. Wenham.—In an article by F. H. Wenham, Esq., of London, published in the 'Quarterly Journal of Microscopical Science' for July, 1854, I have noticed the following paragraph:—

"These experiments [made by Mr. Wenham] will readily account for the difficulty of discovering the markings or structure of a severe test when mounted in balsam; for as thus seen it may be inferred that no aperture exceeding 85° can be made to bear upon it, and this is even supposing that the largest aperture object-glass that has ever been constructed is used. Such being the case I am somewhat puzzled at an announcement that appears to contradict this fact, coming from one that must be considered as authority in these matters. I refer to Professor Bailey, who, in a letter addressed to Matthew Marshall, Esq., dated January 20, 1852, first speaks of an American object-glass of very large aperture (172½°), and its performance on the *most difficult tests known*, and then proceeds to say, 'In all these cases (and in fact whenever I allude to a test-object) I mean the *balsam*-mounted specimens. The *dry* shells I *never* use as tests.' This assertion seems to me to be extraordinary, and very like saying that an aperture of 85° or 90° will do everything that is required. I have invariably found that when very difficult tests are mounted in balsam I cannot discover the markings, and certainly the reasons herein given will account for it. It is to be hoped that the American opticians have discovered some new and peculiar principle in object-glasses, that will render a smaller amount of aperture serviceable; but however this may be, I think that Professor Bailey's statement requires some explanation."—*Journ. Mic. Science, July*, 1854, p. 215.

It is apparent from the above that Mr. Wenham has convinced himself, both by "reasons" and experiment, that I *ought* not to have seen the markings on delicate test-objects when mounted in balsam; and that as he invariably found that he could not discover these markings, therefore some new and peculiar principle in object-glasses must have been discovered to account for the success of American opticians. In answer to this I would state that both in print, as well as in private letters, I stand fully committed to the statement that I can resolve the most difficult tests known *even when mounted in balsam*. In 1849 I stated in this Journal, vol. vii., p. 268, that "the resolution of these tests mounted *dry* is so

much easier than when in balsam, that objects thus mounted are of little value in testing the powers of lenses, although they may answer well when the end is to make out the real structure of the object itself." In fact I have up to this time met with no object which, when mounted *dry* presents sufficient difficulty to rank as a severe test-object, while there are many which when balsam-mounted become very satisfactory.

It is certainly no duty of mine to explain why Mr. Wenham has failed in his attempts to resolve the balsam-mounted specimens, particularly as the resolution of such tests is a matter of every-day amusement with microscopists in this country, and I believe Mr. Wenham does injustice to the microscopists and microscopes of London, in representing the English glasses as incapable of doing as much. That the English lenses are capable of performing well on balsam-mounted objects of considerable difficulty I know by my own trials, some of which are referred to in the following paragraph from a paper recently published in the 'Smithsonian Contributions to Knowledge,' vol. vii., p. 14 :—"I would here state that in the spring of 1853, I resolved the Greenport *Grammatophora* [balsam-mounted] unmistakably by a 1-4th of an inch objective made by Spencer, and subsequently by a 1-4th recently made by Powell of London for Dr. Varnarsdale of New York."

As Mr. Wenham does not mention the names of the test-objects employed by him, I cannot say that they may not be more difficult than any known to me ; yet I feel no hesitation in challenging him to produce an object resolvable when dry, which I cannot resolve when balsam-mounted. I will also state that I at present know of no test-object more difficult than a supposed variety of *Grammatophora stricta*, Ehr., from Halifax, N. S. This is as much more difficult than the Providence *Grammatophora*, as the latter is more difficult than the Greenport specimens. As a supply of the last two varieties has been in London for two years they are probably known to Mr. Wenham, and may have been subjected to experiments by him. That the balsam-mounted specimens of all these objects can be satisfactorily resolved is well known to American observers ; and the following statement given by Judge A. S. Johnson, in vol. xiii., p. 32 of this Journal, is fully confirmatory of my own experience. Speaking of a new object-glass of 174½°, made in July, 1851, by Spencer, the following remarks are made :—

"The light failing us as evening was approaching, we did not try in this way either the Amici test or the Providence

Grammatophora, but in the evening we saw both these objects [balsam-mounted] satisfactorily resolved into dots by unreflected oblique light from one wick of a common bed-chamber lamp, burning oil, a homely but very effective method of illumination for objectives of large apertures."

It appears then that the resolution of balsam-mounted specimens of difficult test-objects *can* be accomplished, in spite of Mr. Wenham's arguments and experience to the contrary. The error in his arguments will be sufficiently obvious to any one who will trace the course of a divergent pencil of rays *out of* the balsam instead of *into* it, as in Mr. Wenham's experiments, and it will then be seen that large angles of aperture are as useful for balsam-mounted specimens as for others. I leave the defence of large angles of aperture to the professed optician, being well satisfied that, notwithstanding the extraordinary attempts made by certain writers in England to underrate the value of the improvements made in this direction, no one who has once employed a properly-corrected object-glass of large aperture will ever be satisfied with one of a different construction.—PROFESSOR J. BAILEY, *in American Journal of Science and Arts.*

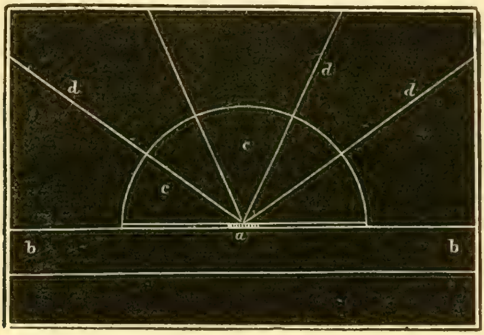
Aperture of Object-Glasses in relation to Objects in Canada Balsam.—In continuation of this subject I have to bring forward a few experiments recently made, for the purpose of viewing objects with the *full aperture* of the object-glass, when mounted in Canada balsam.

The fact that balsam does diminish the angle of aperture of the microscopic object-glass when in action for viewing a structure, mounted in the substance of that or any other refractive medium, has already been sufficiently demonstrated, both theoretically and practically, in the papers of Professor Robinson and myself; and I consider that no further proofs are requisite for establishing the truth of a position, which a few simple experiments can be made to convey the most direct conviction to unassisted eyesight, and which is so strictly based upon the very first laws of incidence and refraction. A fact so obvious as this can only be disputed for two reasons—either ignorance of these laws, or a doubt of their accuracy. To argue the point on one or both these grounds would be beyond my province or capacity; I, therefore, take this as a reality not to be disputed, and as such proceed on the strength of it.

The sharpness and beauty with which *some* test-objects are displayed under the diminished aperture, consequent upon balsam-mounting, is upon first consideration rather surprising,

and tends to show analogically the very great increase of distinctness that would be obtained if the object could be seen in the same medium with the *full aperture* of the object-glass. Having been rather curious to know if objects in balsam could be observed under such an advantage, I have tried a few experiments, which were successful in their results.

I first took a small *hemispherical lens*, of about 1-90th of an inch radius, and cemented it over a selected specimen of one of the *Diatomaceæ* (*N. sigma*) with Canada balsam, in the manner represented by the annexed diagram. A, the object;



b b, slide upon which it is mounted; *c c*, hemisphere of glass covering the object; *d d*, pencils of rays diverging from the object—these may also be considered to represent the aperture of the object-glass. It will be seen from the position of the object, that each ray of light passing from that point through the surface of the hemisphere, will be transmitted in straight lines, in a radial direction, without undergoing any refraction; the consequence of which is, that the full and undiminished aperture of the object-glass is made to bear upon the object.

If an object is already covered with thin glass, it may be surmounted with a lens, so far short of a hemisphere as the thickness of the cover, which of course amounts to the same in effect as if the lens were hemispherical. I have a specimen of *P. formosum*, mounted in this manner, by which the markings are remarkably well displayed. A more simple method of obtaining a similar result is by the following course of proceeding:—Spread some of the desired forms of *Diatomaceæ* upon a glass slip while in a moist state, and when dry, scatter a number of small fragments of hard Canada balsam upon the same surface; apply heat *very gradually*, and these will each run into the form of a spherule; they will

next slowly sink into a shape approaching to that of a hemisphere. Before this figure is quite completed, place the slide under the microscope, and ascertain if any one of the nodules of balsam exactly covers a fair specimen, if not, the trial must be repeated with a fresh slide. Having found an object properly situated under the particle of balsam, the next step is to bring the latter down to the form of a hemisphere, by the further aid of heat very cautiously applied.

The nodule of balsam, having been too spherical in the first instance, will now gradually sink, and must be repeatedly tested under the microscope till the perfect hemisphere is obtained, without any refraction being produced on the rays from the object in the centre. The criteria for knowing this are:—First, the object under the balsam must be *in the same plane of focus* as similar dry objects outside; secondly, the balsam object must not appear *magnified* more than its uncovered fellows; and thirdly, the balsam-covered object should not require a different adjustment from the dry ones on the same slide. The existence of these combined conditions indicate a perfect hemisphere.

When an object is seen under these circumstances, it at once shows the great increase of distinctness that is to be obtained in the structure of the more difficult Diatomaceous tests when they are thus viewed in Canada balsam, with the full aperture of the object-glass. Markings, which in the neighbouring *dry objects* of the same character are scarcely discernible, are sharply and distinctly visible under the balsam hemisphere with the same illumination.

The luminosity of the field of view around the balsam object is many shades darker than in the uncovered portion of the slide, which appearance is caused by the diminished angle or cone of rays of the illuminating pencil. From this fact it is evident that the theoretical perfection of mounting objects in this manner would be to enclose them exactly in the *centre* of a minute sphere of balsam. In this case the pencil of rays, both from the achromatic condenser and object-glass, would pass directly to the object without refraction or diminution; but I must confess that I have not been successful in effecting this. It is very easy to form a sphere of balsam at the end of a needle-point of any required degree of minuteness, but very difficult to coax an object into the centre of such a spherule.—F. H. Wenham.

Microscopical Conversaziones.—Few events have excited more interest amongst microscopical observers than two soirées, given by Mr. N. B. Ward, as Master of the Apothecaries'

Society. Those who have used the microscope for many years in London will not have forgotten the pleasant reunions at Mr. Ward's house in Wellclose-square, when this instrument was in its infancy, and when it required some courage to confront those who maintained that at best it was a toy, and its use a loss of time. The soirées of March 7th and April 11th might well be regarded by Mr. Ward and his friends as a vindication of their early zeal, and a triumphant demonstration of the value and importance of the instrument whose first successes they had witnessed, and whose influence on human knowledge has more than realized their warmest anticipations. The rooms at the disposal of the Apothecaries' Society were well adapted to entertain a large audience, and perhaps in their history were never more gracefully employed than in presenting what has been effected by an instrument that has so largely contributed to the advancement of medical science. On each occasion the walls of the large hall were hung round with diagrams and drawings, exhibiting enlarged representations of various objects observed by the microscope. They were arranged according as these were from the mineral, vegetable, and animal kingdoms. Each kingdom was again subdivided into particular groups; and beneath these diagrams, on tables, were placed microscopes, by which could be examined either the objects themselves which were represented, or others allied to them. On both occasions nearly one hundred microscopes were exhibited. All the best forms and the newest apparatus might be seen at work. Mr. Shadbolt, Mr. Brooke, Mr. Furze, and Mr. Wenham, were superintending their respective methods of illumination. The ingenious machine of Mr. Peters', described in the Transactions of the Microscopical Society, in the present number of our Journal, was exhibited at the second soirée for the first time; and writing produced upon glass which defied the highest powers of the best microscopes to decipher. Mr. Rainey and Professor Quekett exhibited a large number of very beautifully injected specimens of animal tissues. Amongst a variety of other objects Mr. Rainey exhibited the curious glands in the frog's skin, described by him in the present number of the Journal. Mr. Mummery, of Dover, to whom science is indebted for many valuable observations on marine animals, brought with him a quantity of living specimens, and thus enabled a large number of persons to witness, for the first time, the beautiful movements of the Cilio-brachiate Polyps, the currents in the Sponge, and other objects. Mr. Cook, the artist, whose Fern cases are almost as celebrated as his pictures, exhibited a great

variety of specimens of the fructification of Ferns and Mosses. The same class of objects were exhibited by Mr. Loddiges. Mr. Bowerbank exhibited a series of the anchor-like processes from the Holothuriadæ and Polyps. Mr. Varley exhibited *Chara*, *Valisneria*, and living Animalcules. The Rev. J. Reade exhibited a series of crystalline bodies; whilst Mr. Woodward threw a new light on every object by his beautiful polarising apparatus. Plants, pictures, and objects of general interest crowded the tables; but these were rather the adornments than the substantial entertainment of the evening. Were we to give an account of all that was worth seeing, it would take up too large an amount of our space. We have felt ourselves justified in giving these soirées this notice, both on account of the respect we feel for the Master of the Apothecaries' Society, at whose suggestion these interesting soirées were arranged, and for the intrinsic benefit which must arise from presenting to the mind at one time so large a number of the facts which have been discovered by the aid of the microscope. We are glad to be able to add that the friends of Mr. Ward are raising a subscription for the purpose of presenting his portrait to the Linnæan Society, to be placed amongst the collection of portraits of distinguished naturalists in the meeting-room of that Society.—E. L.

Cheap Microscopes.—We announced in our last number that the Society of Arts had offered two prizes for cheap microscopes. From the following extract from the Report of the Committee of that Society it will be seen that it has succeeded in obtaining this desirable object:—

"The important position which the Microscope now holds, not only in relation to pure but to applied science, and its great value in assisting to form those habits of observation which it is the object of all sound education to impart, induced the Council to believe that the promoting the production of a good instrument at a price which should render it more readily accessible to the many, was an object worthy of the Society; and, accordingly, under the advice and with the assistance of a Committee, composed of Mr. Busk, F.R.S.; Dr. Carpenter, F.R.S.; Mr. Jackson; Dr. Lankester, F.R.S.; Mr. Quekett; and Mr. W. W. Saunders, F.R.S., the following prizes were offered:—

For a *School Microscope*, to be sold to the public at a price not exceeding 10*s*. 6*d*.—*The Society's Medal.*

For a *Teacher's* or *Student's Microscope*, to be sold to the public at a price not exceeding 3*l*. 3*s*.—*The Society's Medal.*

The Council undertook to purchase 100 of the smaller, and

50 of the larger instruments for which the medals should be awarded.

"The members will be glad to learn that for these prizes there have been numerous competitors. After most carefnl examination of all the instruments by the Committee, they unanimously reported to the Council that the instruments sent in by Messrs. Field and Co., of Birmingham, fulfilled all the conditions required, and the Council have, therefore, awarded to that firm the medals offered, on Messrs. Field and Co. entering into the necessary undertakings to comply with the requirements of the Prize List. The Council congratulate the members on this result. Those members who are desirous of securing any of these instruments, which will shortly be supplied to the Society by Messrs. Field, at a discount of 10 per cent., should at once send in their names to the Secretary."—*Excerpt Annual Report of the Council of the Society of Arts to the Members, presented at the General Meeting, June* 13, 1855.

On "Species" of Diatomaceæ.—In your Journal for January Professor Smith has made some valuable observations on what is a *species* among Diatomaceæ, in which he enforces the necessity of studying these beings in the recent state before one can decide on what ought to be reckoned distinct. This is the more necessary as it appears to me that neither size of the frustules or distance of the striæ are sufficient to distinguish species, unless we allow to each a very considerable range of variation.

What are called "species" in Diatomaceæ may be viewed under a twofold aspect:—1st. A species as it exists in nature, requiring a study of every state from the sporangium to the sporangium-bearing individual: 2nd. As serves the purposes of the microscopist, who gives names to every difference of form or size he observes that is not already figured. To the latter class may be referred most of Ehrenberg's, Kützing's, and Gregory's species; and it would be preferable to indicate them by 1, 2, 3, &c., to giving names to each, until Smith or some other naturalist can ascertain to what genuine species such forms may be referred. It is a natural species alone which is worthy of the attention of scientific men.

A diatom increases in two different ways—by sporangia, and by self-division. The length of time before a diatom produces sporangia probably varies considerably in different genera, and even in different species, but seems rarely, if ever, to be less than three or four months. On the other hand the power of self-division, although supposed by some to belong

only to the mature frustule, seems really to exist at a very early age, as soon indeed as a frustule is formed from the sporangium. Between the young state and the fully-formed or sporangial one there must thus be a considerable difference in size; and, as the number of frustules (the produce of one sporangium by self-division) increase in a geometrical progression, we may always expect to find many more of the larger than we did a short time previously of the smaller size, in the same pool. All the frustules from the same sporangium exhibit probably nearly the same size at the same age; but in the same locality other sporangia may have been deposited, so that we find the same species of different ages or sizes mixed together. The minimum and the maximum state is therefore one of the points that require to be decided on by naturalists before we can form a definite idea of any one species.

The striæ on the valves of a species requires also to be studied; and here the question arises, is the distance between the striæ, or their number in ·001 inch, constant? or does the distance vary with the size of the valve, the number on the entire valve being constant, when the frustules are all the produce of the same sporangium? So long as this remains undetermined by actual observation, it is of no use counting the number of striæ in a given space, or of talking of any species being a test for object-lenses. Mr. Sollitt, of Hull, in giving the number of striæ of *Pleurosigma quadratum* and *angulatum* (Microscopical Journal, II., p. 62, when by *P. angulatum* he meant *P. quadratum*, and by *P. strigosum* is meant *P. angulatum* of Smith), points out a considerable difference between the distance of the striæ in small and large specimens, and that they are more distant in the latter; as however he does not give the exact length of the frustules, nor say that the valves were found in the same gathering, or if obtained from the same locality at some weeks' distance of time, no positive conclusions can be drawn from his measurements. So far as my own observations go, the number of striæ in the entire valve is tolerably constant, whether small or large, when obtained at the same season and from the same locality; and consequently the actual number in ·001 in. is of less consequence than generally supposed, unless we multiply that number by the length of the valve. Smith's β and γ of *Pleurosigma Balticum* seem to have nearly the same total number of striæ, as in his α; but the first is about half the size of γ, and the other about one-third; so the striæ in these ought to be from two to three times closer than in α, and this agrees well with observation: these two, then, cannot be considered in the light of *varieties* of α, but merely a younger state of the

same diatom. Other instances might be mentioned in which the total number of striæ is more constant than the number in ·001 in. It is obvious that if the number in ·001 in. be constant at all ages, we must allow that in passing from the youngest state to maturity the valves have the power of adding new striæ as they grow larger, but whether these additions are at the extremities or at the centre no one has taken the trouble to investigate. It may be alleged that the new valves formed by the process of self-division acquire more numerous striæ than before; but while it is generally conceded that one of the old valves remain in each frustule, this explanation can scarcely be admitted, unless we are prepared also to allow that there may be a great dissimilarity in the striæ between the two valves of the same frustules. If the total number of striæ in the valves remain constant, we must suppose the striæ to separate slightly as this valve enlarges; and this supposition appears to me more in accordance with observations hitherto recorded, although, no doubt, such observations have not been made directly in reference to this point.

If the number of striæ on the entire valve be found more constant than the number in a given space (and here some allowance must be made for the produce of different sporangia not being identically the same either in size at the same age, or in the precise number of striæ to each valve), we may often have a criterion whereby to decide whether a frustule be the young state of a species or a distinct species or variety. I have alluded to the β and γ of *P. Balticum* not being entitled to rank as varieties, any more than a lamb is a distinct *variety* of a sheep; but, on the other hand, if we examine *Nitzschia dubia* of Smith, we shall find not only that his β is much smaller than the α, but that while the striæ of α are difficult to be resolved by a $\frac{1}{4}$ those in β are readily made out, being more distant. The small state here has more distant striæ than the large one, and although sometimes mixed in the same gathering cannot possibly be the young of the other; it may form a peculiar variety, but my observations tend to allow it the rank of a species, if indeed it do not belong to a different genus.

Sufficient attention has not yet been paid to the sporangial state of the diatoms; from the observations recorded by Thwaites, Smith, and others, different genera seem to follow different laws on the subject. In *Navicula* this state appears to be always accompanied by a great dilation of the frustule, and the formation of a strong line or band between the median line and the margin; sometimes the new line is nearly straight and parallel to the median line except near the nodule, with

which it seems connected; sometimes it is curved; but whether both structures occur in the same species, or are indicative of different species, no evidence has hitherto been adduced. Smith's figures 152*a**, 154*a*, and 274*a*, may be taken as examples of the one, and 152*a*, 153*a*, and particularly 153*a* and 154*a**, of the other. The striæ appear, however, to preserve nearly the same inclination to the new or intermediate lines which they did in the non-sporangial state to the median line; and hence the direction of the striæ is not sufficient of itself to distinguish species, however good a character it may afford, unless regard be had to the peculiar state of the frustule.

Perhaps I may be allowed here to remark that from the days of Linnæus it has been a maxim, although specimens be distributed or figures given with names, such names are held to be unpublished unless clear and precise specific and generic characters be given along with them; and that he who gives such characters is not bound, except through courtesy, to adopt or refer to the names attached to new figures. The reason is obvious; specimens or figures only exhibit one form of the species, and afford no information as to its limits, and consequently the same author may, from ignorance of the laws on which species are to be founded, give representations of several forms of the same species; such names, if all the forms were specifically distinct, may be good, but bad when they are to be united; the describer or naturalist must, therefore, not be hampered by the errors of the artist or microscopist who preceded him. In Ehrenberg's Mikrogeologia, the most unphilosophical work ever published on Diatomaceæ, not one species, although supposed new, is characterized; and unless one has samples of the same deposit he has depicted, it is quite impossible to guess with any degree of certainty what he intends, unless in some very rare instances. His *Biblarium glans* is readily seen, no doubt, to be the well-known *Tetracyclus lacustris*, of which Ehrenberg appears ignorant, and his *Synedra ? hemicyclus* to be *Eunotia falx* of Gregory, but few others can be so readily made out. In this respect Kützing's works have an advantage over Ehrenberg's; but in many cases Kützing merely derives his specific character from Ehrenberg's figures and not from the diatom itself, thus adding to the confusion. In the same way in your Journal are several papers by Dr. Gregory, accompanied with figures, but as no specific characters are assigned the figures lose their value, as no one is bound to adopt the names there given.

In characterizing species a great mistake has crept in of late years not only as to diatoms, but as to flowering plants;

a species is defined, and then we get β, γ, δ, &c., noticed as varieties, each with characters at variance with the character of the species. A genus must be characterized so as to include *every* species referred to it; and in the same way a species must have a character that will include all its varieties, or at least not exclude any one of them. No one has a right to say which variety is the type of a species, when all may have arisen from the same original seed; the primitive form may be β, or ϵ, or λ, of that we are totally ignorant. All we can do is to arrange the varieties according to some arbitrary rule, and to define each, α as well as θ, or π; the peculiar character of α cannot be incorporated with the diagnosis of the species without doing violence to the other varieties, and in fact separating them as distinct species, although the author has not had the courage to do so, from indeed feeling convinced they are not so.

Although I consider the *distance* between the striæ to depend considerably on the age and size of the frustule, I wish it to be distinctly understood that as yet we have not sufficient information whether the *number* of striæ may not also vary slightly in the same way. It is possible that both variations take place; but until the law connecting them be ascertained, all attempts to derive specific characters from the striæ are futile, if not injurious, to the science, unless we allow a very considerable range, so great indeed as to destroy the utility of such characters. If, as some microscopists think, the striæ are the walls, and dots the angles formed by the walls of minute compressed cellules, the surface of the valve of a diatom ought to be compared with the cuticle of a flowering-plant, which consists of cellular tissue so highly compressed that the upper and lower walls touch each other, leaving the lateral ones in the form of reticulating veins, these vein-like reticulations having a certain thickness as well as height: in viewing these by direct light, we see only the breadth of each line, while obliquely, or by oblique light, causing an oblique shadow or picture to enter the object-glass, we see also its height, and therefore a greater surface of the reticulating lines reaching the eye by oblique than by direct light, we see these lines more distinctly. If the striæ of diatoms be formed in that way, we might easily understand that the ease of making them out does not depend on the distance from each other so much as on the breadth of the lines or dots in connexion with their elevation; and therefore, although the actual distance of such be the same, we may resolve some frustules of the same species more easily than others. Diatomaceæ are thus not so good tests for the micro-

scope as supposed, unless the same slide be used by all observers.—A.

On a New Locality of Microscopic Test-objects.—In a Smithsonian memoir published in February, 1854,* I have described and figured a species of *Hyalodiscus* from Halifax, Nova Scotia, which appeared to me to be admirably fitted for a test-object, inasmuch as its circular form, with radiant and curved lines of great tenuity proceeding in all directions, renders it unnecessary ever to change the position of the shell when in the field of view in order to secure the best possible direction of the light. Whatever its position, on account of the perfect symmetry of its form and markings, some portion must always be in the best possible position with reference to the oblique light used for its examination. Unfortunately, the Halifax specimens of this beautiful object appear to be quite rare, I am therefore happy to announce the discovery upon various Algæ from Monterey, California, of an inexhaustible supply of a species of *Hyalodiscus* closely allied to the Halifax species, and answering equally well as a test-object. I find it so convenient as a test-object when *balsam-mounted* that I am sure it will find favour with lovers of the microscope.—Professor J. Bailey, *in American Journal of Science and Arts.*

Memoranda on Flies' Feet.—In the Journal, Vol. iii., p. 230, Mr. Tyrrell, of Newcourt, remarks, "In confirmation of Mr. Hepworth and other naturalists, that the use of the cushions beset with hairs terminating in glands secreting a glutinous substance, is to attach the foot to the surface upon which the insect walks by means of such secretion, and not by suction, I would suggest that the hooks on the feet of flies are intended not to attach the Fly to anything, but to be used as fulcra, or props, which it can push against when it wishes to detach the cushions. Without the hook-shaped props, the Fly, when once *stuck fast, must remain so.*"

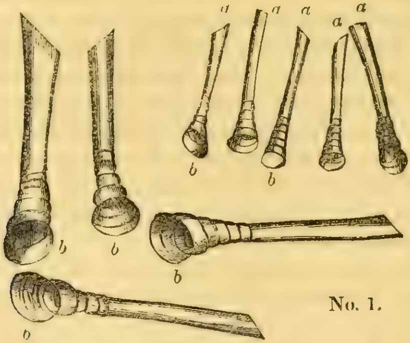
Mr. Tyrrell alludes to a paper in the previous Volume on the 'Fly's Foot,' in which I state that this fluid is not essential for that purpose (of attaching the foot), and I speak of the tubules as suckers. My observations have led me to the following conclusions: viz.: that the termination of each hair or tubule is a sucker, and the secretion is only to increase its

* 'Notes on New Species and Localities of Microscopical Organisms,' by J. W. Bailey, in 'Smithsonian Contributions to Knowledge,' Vol. vii., p. 14.

power, on the same principle as that on which the boy wets his leather to attach it to a stone; that the fluid is not of a glutinous nature, as it evaporates very rapidly, and I have not been able to detect anything on the glass afterwards, when the foot has been perfectly clean: that each sucker is under the influence of the will, and has either muscular fibres or other elastic tissue, which answers the same purpose (*vide* Professor A. Ecker's paper, Journal, Vol. ii., page 111). If the secretion were glutinous, and the foot were to be attached for some time (twenty or thirty minutes, as I have often seen it) to the same spot, it would get so firmly fixed, that if forcibly raised by the leverage of the hooks, these exceedingly delicate structures would be destroyed. The *Dytiscus*, when under water, is able to hold himself so firmly on glass, as to require the weight of many pounds to overcome the power with which he is attached; whereas when the glass is dry, there is no difficulty. I have seen a Fly (under the microscope feet upwards) make one foot the centre of motion, and move the body so far round it, as to cause the leg to form a considerable angle (15 to 25 degrees). I conceive that, to overcome the adhesion, if produced by a glutinous secretion, which is sufficient to fix the foot under these circumstances, it would require such an amount of power by means of leverage, as would readily tear through the delicate ends of the tubules. At other times, I have seen the insect so far loosen its hold, as to allow the flap (cushion) to drag along the glass, and refix it firmly, without lifting it off the glass. The round portion of the flap of the blow-fly is about the 1-100th of an inch in diameter, which contains upwards of 6,000 suckers; the triangular part, extending for attachment up to the leg, will be about a quarter more of that area: the flaps of one foot, then, will have 15,000 or 16,000 points of attachment. Diagrams, Nos. 1 and 2, are further illustrations of the same principle. No. 1—Hairs from the pad of the foot of a small *Curculio* beetle; they expand into the form of a trumpet, and where the expansion commences they appear corrugated, and the corrugation is continued to their extremities; the expanded parts are extremely attenuated, so much so, as to require a high power and oblique light to make them out. These insects (not being aquatic) also secrete a fluid for the same purpose as the Fly: and I can imagine that if, after the ends have been attached and moistened, these folds could be put upon the stretch, thereby lengthening the tubes, and consequently having a tendency to produce a vacuum, they would form an excellent apparatus for attachment.

No. 2 is the pad of a variety of *Cymbex lutea*, which has

hairs similar to those of the flap of the Fly; the wing of this insect possesses hooklets.



No. 1.

No. 1.—Hairs of *Curculio* Beetle. *a*, *a*, *a*, shaft of hair; *b*, *b*, *b*, expanded ends. 400 diameters.

No. 2.—Leg of *Cymbex lutea*. *a*, *b*, *c*, *d*, cushions at each joint. 24 diameters.

No. 3.—Enlarged view of *c*, showing hairs on the under surface. 110 diameters.

No. 2.

No. 3.

JOHN HEPWORTH, *Croft's Bank*, *May* 31, 1855.

On Finders.—Contributors to these Notes have suggested many successful contrivances for indicating the exact position of an object in a slide, but they all involve an amount of complex arrangement which is inconvenient in their practical application under a moderately-high power. A small, narrow ring, painted round the object on the surface of the thin glass cover with Prussian blue water-colour, will at last prove the most serviceable, because it can at once be seen, when in the field, without altering the focus, and more readily than a ring

marked by a diamond, to which the focus must be first directed. A little practice will soon lead to dexterity in estimating the position of the object when the slide is on the stage, and in making a touch or a line of colour thereon as a guide for the position of the ring; the work can be examined under the microscope, and corrected and finished in any convenient position. A red ring painted outside the blue will render it more conspicuous, and assist observation when under the microscope; the colour should be used rather thick, and the whole should have a slight protecting coat of gold size or varnish. As objects are mounted for other purposes than to furnish neatly the drawers of a cabinet, the facility in using slides thus permanently marked will outweigh the objections to the unsightly appearance.—J. H.

Memoranda on the Employment of Artificial Sea-Water in Marine Aquaria.—Early in the summer of last year I commenced some experiments on artificial sea-water, made according to the formula proposed by Mr. P. H. Gosse; the ingredients in the proper proportions having been procured from Mr. Wm. Bolton, 146, Holborn Bars, London. In it I have successfully maintained alive the following marine productions:—

ANIMALS.

Zoophytes.

1. Clava multicornis.
2. Hydractinia echinata.
3. Actinia Mesembryanthemum.
4. „ crassicornis.
5. „ bellis.
6. „ parasitica.
7. „ Dianthus.
8. „ anguicoma.
9. „ clavata.
10. „ Aurora.
11. Anthea cereus.
12. Caryophyllia Smithii.
13. Sertularia polyzonias.
14. „ filicula.
15. „ pumila.
16. Flustra membranacea.
17. Bowerbankia imbricata.
18. Vesicularia spinosa.

Annelides.

19. Serpula contortuplicata.
20. „ triquetra.
21. Sabella —— ?
22. Terebella conchilega.
23. Spio vulgaris.
24. Nereis —— ?
25. Pontobdella muricata.

Mollusca.

26. Cynthia momus.
27. Pecten opercularis.
28. Doris pilosa.
29. „ tuberculata.
30. Eolis coronata.
31. Nucula cristata.
32. Lamellaria perspicua.
33. Nerita —— ?
34. Littorina littorea.
35. Rissoa —— ?
36. Trochus zizyphinus.
37. Purpura lapillus.
38. Chiton fascicularis and C. lævis.

Cirrhipedes.

39. Balanus balanoides.
40. —— —— ?

VEGETATION.

41. Ulva latissima.
42. Enteromorpha compressa.
43. Cladopora —— ?
44. Phyllophora rubens.
45. Bryopsis plumosa.

The only accommodation provided for the whole of the above is a series of glass jars and vases placed on shelves in the windows of an ordinary London dwelling-room, the largest glass not exceeding three gallons capacity. It is not pretended, however, that those animals, which are notoriously short-lived in confinement (such for instance as Nos. 27 to 32) even under the most advantageous circumstances of space, had their existence more prolonged with me: I would merely state that I have met with no more difficulties with the artificial than with the actual sea-water, under the same conditions. Nos. 1, (this is now in the gravid state represented in Johnston's Zoophytes, Plate 1), 2 and 16, made their appearance, spontaneously as it were, on some empty shells and other debris placed in the water six months before, and which had not been changed during the whole of that period. Nos. 3, and 5 to 10, are very hardy with me, but No. 4 is in general precarious. Nos. 13, 14, 15 lived in a quart jar for three months, at the end of which time I disposed of them, after they had added hundreds of new cells to the polypidoms. Nos. 19, 20, 21 added considerably to their tubes, the new portion being indicated in No. 20 by its superior whiteness, and the rate of increase being about a third of an inch in six months. On the 1st of May, I counted ten young of this species, the parents having been in my possession since September 4. Colonies of No. 23 are very vigorous and active, but I find that they have a period of rest from soon after midnight to about 4 or 5 P. M.

Many of the *Actiniæ* mentioned in the above list are the same individuals which I had at the commencement of my experiments, and most of them have brought forth young abundantly. The development of Nos. 16 (this especially), 17, 18 have afforded me many weeks of most interesting observation. In Nos. 39 and 40, I have noticed that frequently the cirrhi have began to play as quickly as ever, even after a period of inaction so long that I have supposed the animals to be dead.

In the vegetation, I find that No. 42 is the most effective in the evolution of oxygen. No. 41 stands next. No. 44 is apt to decay if not placed in a shaded spot, but it is always interesting from the quantity of parasitic animals usually found upon it.

I trust that these desultory observations, hastily thrown together, but scrupulously containing nothing that I have not personally witnessed in my own collection, will have the effect of increasing the domestication of the interesting productions of our shores.—William Alfred Lloyd, 164, *St. John Street Road, Islington, London, June* 6, 1855.

PROCEEDINGS OF SOCIETIES.

Royal Society.

Mr. Savory, "*On the Development of Muscular Fibre in Mammalia.*"

The author's observations were made chiefly upon fœtal pigs; but they have been confirmed by repeated examinations of the embryos of many other animals, and of the human fœtus.

If a portion of tissue immediately beneath the surface from the dorsal region of a fœtal pig, from one to two inches in length, be examined microscopically, there will be seen, besides blood-corpuscles in various stages of development, nucleated cells and free nuclei or cytoblasts scattered through a clear and structureless blastema in great abundance. These cytoblasts vary in shape and size; the smaller ones, which are by far the most numerous, being generally round, and the larger ones more or less oval. Their outline is distinct and well defined, and one or two nucleoli may be seen in their interior as small, bright, highly-refracting spots. The rest of their substance is either uniformly nebulous or faintly granular.

The first stage in the development of striated muscular fibre consists in the aggregation and adhesion of the cytoblasts, and their investment by blastema so as to form elongated masses. In these clusters the nuclei have, at first, no regular arrangement. Almost, if not quite as soon as the cytoblasts are thus aggregated, they become invested by the blastema, and this substance at the same time appears to be much condensed, so that many of the nuclei become obscured.

These nuclei, thus aggregated and invested, next assume a much more regular position. They fall into a single row with remarkable uniformity, and the surrounding substance at the same time grows clear and more transparent, and is arranged in the form of two bands bordering the fibre and bounding the extremities of the nuclei, so that now they become distinctly visible. They are oval, and form a single row in the centre of the fibre, closely packed together side by side, their long axes lying transversely, and their extremities bounded on either side by a thin, clear, pellucid border of apparently homogeneous substance.

It is to be observed how closely the muscular fibres of mammalia at this period of their development resemble their permanent form in many insects.

The fibres next increase in length and the nuclei separate. Small intervals appear between them. The spaces rapidly widen, until at last the nuclei lie at a very considerable distance apart. At the same time the fibre strikingly decreases in diameter; for as the nuclei separate, the lateral bands fall in and ultimately coalesce.

This lengthening of the fibre and consequent separation of the nuclei is due to an increase of material, and not to a stretching of the fibre.

Soon after the nuclei have separated some of them begin to decay. They increase in size; their outline becomes indistinct; a bright border appears immediately within their margin; their contents become decidedly granular; their outline is broken and interrupted; and presently an irregular cluster of granules is all that remains, and these soon disappear.

It sometimes happens that the nuclei perish while in contact, before the fibre elongates; but the subsequent changes are the same.

The striæ generally first become visible at this period, immediately within the margin of the fibre.

The fibre is subsequently increased in size, and its development is continued by means of the surrounding cytoblasts. These attach themselves to its exterior, and then become invested by a layer of the surrounding blastema. Thus, as it were, nodes are formed at intervals on the surface of the fibre. These invested nuclei are at first readily detached, but they soon become intimately connected and indefinitely blended with the exterior of the fibre. All its characters are soon acquired; the nuclei at the same time gradually sink into its substance, and an ill-defined elevation, which soon disappears, is all that remains.

Lastly, the substance of the fibre becomes contracted and condensed. The diameter of a fibre towards, or at the close of intrauterine life, is considerably less than at a much earlier period.

At the period of birth muscular fibres vary much in size.

The several stages in the development of muscular fibre, above mentioned, do not succeed each other as a simple consecutive series; on the contrary, two, or more, are generally progressing at the same time. Nor does each commence at the same period in all cases.

Stoke Newington Natural History and Scientific Society.

April 24, 1855.

A paper was read by Mr. Richard Moreland, jun., 'On the probable Structure of the Starch Granule.' *

After pointing out the extensive occurrence of starch in the vegetable kingdom, and its importance in an economical point of view, and adverting to its chemical properties, the author proceeds to discuss the structure of the grain itself. He illustrates his views on this point by reference to the form of starch termed 'tous les mois arrowroot,' the large grains of which are particularly fitted for observation.

Noticing the views of Leuwenhoek, Rastail, Fritzsche, Schleiden,

* This paper, accompanied with elaborate figures, has been forwarded to us for insertion; its length, however, renders this impossible, and we have been compelled to content ourselves with the above abstract of Mr. Moreland's views.—Editors of Quarterly Journal of Microscopical Science.

Martin, &c., Mr. Moreland declares himself in favour of those who conceive with Schleiden and others, that the starch granule is constituted of successive layers or laminæ, inserted one within the other, and whose edges are represented by the concentric markings seen on the surface of the grain. He advocates, in fact, the view propounded in a late number of the 'Quarterly Journal of Microscopical Science,' by Professor Allman.

The principal additional argument relied upon by Mr. Moreland in support of this opinion, appears to be derived from the use of polarized light in the examination of the grain, whilst undergoing solution in sulphuric acid. Observing that the crop of polarization continues to be well defined after the dissolution, or, as he terms it, the disintegration of what he regards as the outer layers by the action of the acid, he conceives that this circumstance is sufficient to indicate that the grain is constituted of a succession of such laminæ of like consistence throughout.

He also notices the effect of chloride of zinc upon the starch grain, which, he says, "instead of disintegrating the vesicle, causes it to expand slowly in the form of a thin membrane."

The paper concludes in nearly the following words:—

"That all starch granules, which exhibit elliptical or striated markings, and are also capable of polarizing light, are composed of a series of vesicles (hollow ellipsoids), any deviation from this form being produced by circumstances attending their formation. These vesicles are thicker at that extremity of the granule from which they receive their sustenance [addition to their substance], consequently the nucleus is situated at the opposite extremity. The granules are attached to the cell-wall by that extremity which is farthest from the nucleus; the thickness of the vesicles being indicated by the distances between the markings. They are, moreover, enclosed one within the other, and it may be proved [the author conceives] by sound reason and observation that these vesicles are deposited and formed upon the exterior surface of the one previously existing, and that each vesicle, upon its final development, is a hard, colourless, transparent, homogeneous substance, all being chemically and physically identical, save that a portion of any foreign substance may be deposited with any of the vesicles," &c.

ZOOPHYTOLOGY.

Class. POLYZOA.

Order I. P. INFUNDIBULATA.

Sub-order 1. CHEILOSTOMATA.

§ 1. Articulata.

§§ 2. Bi-multiserialaria.

Fam. SALICORNARIADÆ, Busk.

Gen. Onchopora, n. sp., Busk (Ὄγκος).

Cells ventricose, coalescent; not bordered by a raised margin. Ovicells inconspicuous.

1. *O. hirsuta*, n. sp.? Busk. Pl. III.

A long jointed corneous tube arising on each side on the front and upper part of the cell; a raised median pore, below the mouth, which is produced and subtubular.

? *Cellaria hirsuta*, Lamx. Hist. des Polyp. cor., p. 126. Pl. II., fig. 4, *a*, B.

Hab. New Zealand. Dr. Lyall.

The outward aspect of this species so closely resembles that of *C. hirsuta*, Lamx., that, notwithstanding the apparent differences in the minuter details, so far as they can be ascertained from the imperfect figure above cited, I am strongly inclined to regard them as most probably identical. The polyzoary forms small tufts, constituted of short truncated internodes, united by a single large corneous tube, and having a hairy aspect from the curious, jointed corneous tubes springing from each side of the cell. The little median pore sometimes appears like a very minute avicularium, but it is by no means clear that it is an organ of that kind. The corneous tubes are clearly not vibracula; and as the perfect ones are closed at the end, and free, they do not seem to be of the nature of radical tubes, such as exist, for instance, in *Cauda arachnoidea*.

2. *O. tubulosa*, n. s., Busk. Pl. IV., fig. 1.

Mouth of cell—very much produced, tubular; a median pore in front of the cell.

Hab. Ægean Sea. E. Forbes.

The much-produced tubular prolongation of the mouth in this species, at the end of which there is no indication of a moveable lip, might at first sight lead to the supposition that this form belongs to the second sub-order of the Polyzoa; but further examination, and especially where the tubular portion may be partially broken off, will detect the lip, at the bottom of the tube, in the usual situation. The absence of the corneous tubes at once suffices to distinguish this from the preceding species, from which it also differs very widely in external aspect. The polyzoary is not constituted, as in that case, of short internodes, arising from each other in a dichotomous arrangement, but is formed of cylindrical branches sometimes an inch or more in length, from which others arise at irregular distances, and nearly at right angles, to that from which they spring, and to which they are articulated, not by a single, wide corneous tube, but by a bundle of smaller tubes, in number corresponding to the initial cells of the new branch. It may be supposed to bear some resemblance to the *Cellaria cercoides* of Ellis and Solander (Pl. V., fig. *b*, A, B, C, D, E);

and perhaps may represent a variety of the same species, which is also stated to come from the Mediterranean.

3. *O. mutica*, n. sp., Busk. Pl. IV., figs. 2, 3.

Mouth plain ; crescentric above, with a straight inferior margin.

Hab. Philippine Islands? or Australia?

A minute form, sufficiently distinguished from its congeners by the above character. The polyzoary is constituted of short internodes, connected by a flexible horny tube. The only specimen I have is very small, and it is constituted of short internodes, composed of 8 or 10 cells. Its habitat is doubtful, but I believe it to be one or other of those above assigned. It is growing on a fragment of coral.

Some apology is requisite for the proposal of a new generic term, to a form which has probably been long known under another name ; but in the present case it appeared justifiable, from the consideration that the term *Cellaria*, which is the only one that could have been taken, has been understood in so many senses ; and that the species at different times included under it have been so frequently subdivided into other groups, as to render its continued use likely to produce much confusion.

The species having articulated polyzoaries composed of cylindrical internodes, in which the cells are disposed around an imaginary axis, were originally confounded by Pallas under his genus *Cellularia*, and by Solander under that of *Cellaria*, with many others, not possessing that peculiar characteristic. The term *Cellaria*, however, was subsequently restricted by Lamouroux to those polyzoaries, which had cylindrical branches, or rather in which the cells were disposed around a central axis ; but as this restricted sense of the term has not been adopted by many subsequent writers, nor especially by Lamarck, and as it has long since ceased to be applied to the genus *Salicornaria*, it seems as well perhaps to dispense with it altogether.

Other forms again have been confounded under the same term *Cellaria* by several writers, among whom may be noticed Reuss, in his account of the fossil polyzoa of the Vienna tertiaries, who includes under it *Vincularia*, Defrance (*Glauconoma*, Goldfuss). Whilst Hagenow, on the other hand (Die Bryoz d. Maastrich, Kneidebildung), adopts *Vincularia* and ignores *Cellaria*. In *Vincularia*, proper, however, the polyzoary is continuous throughout, and not subdivided into internodes by flexible joints ; so that there appears to be no reason whatever for associating the two.

The following fossil forms might be referred to the genus *Onchopora* ; and it would appear that no species belonging to it occur in formations anterior to the tertiary, unless the

Ceriopora oculata, Goldf. (Petref. Germ., Pl. LXIV., fig. 14, p. 217), from the transition limestone, may be included in it.

Cellaria duplicata, Reuss, l. c., p. 62, T. vii., fig. 34.
,, *labrosa*, Reuss, l. c., p. 63, T. vii., fig. 35.
,, *Michelini*, Reuss, l. c., p. 61, T. viii., figs. 1 and 2. (*Vincularia fragilis?* Defrance), also in the Paris basin (Michelin, p. 46).
,, *coronata*, Reuss, l. c., p. 62, T. viii., fig. 3.
,, *scrobiculata*, Reuss, l. c., p. 63, T. viii., fig. 4.
,, *Schreibersi*, Reuss, l. c., p. 63, T. viii., fig. 8.
,, *Haueri*, Reuss, l. c., p. 63, T. viii., fig. 9.
,, *stenosticha*, Reuss, l. c., p. 64, T. viii., fig. 10.

We have here also given the figures of a species of *Eschara*, which would seem to correspond very closely with the *Millepora cervicornis* of Ellis and Solander, or with the *Eschara cervicornis* of Lamarck (An. s. Vert., 2nd ed., t. ii., p. 267), though not to that described by M. Edwards (*Sur les Eschares*, p. 15, Pl. I. and Pl. II., fig. 1), under the same name, from which it is undoubtedly different, as it is also from the *E. cervicornis* in the British Museum Catalogue. Neither does it correspond with the *E. gracilis* of Milne-Edwards. From the former it differs widely in the shape of the mouth, and in its tubular projection, and from the latter in the absence of the median pore, and of punctation of the surface of the cells.

But as I have not been able to refer to Marsigli's figure (Hist. de la Mer., tab. xxxii., fig. 152), with which Ellis and Solander's *Millepora cervicornis* is said exactly to agree, I find it impossible at present to come to a definite conclusion in the matter.

Provisionally, it would seem right to regard the present form as the true *Millepora* (*Eschara*) *cervicornis* of Ellis and Solander, and it might be thus characterized :—

E. cervicornis, Solander. Pl. IV., figs. 4, 5, 6.

E. ramosa, ramis subcylindraceis per angustis ; osculis prominalis tubulosis ; labio inferiori, mediò denticulato.

Hab. Ægean Sea. E. Forbes.

The polyzoary is composed of slender, cylindrical branches, in the older and thicker parts of which the cells become deeply immersed, and the mouth appears like a raised nipple, but within it may always be perceived the median denticle on the lower lip.

JOURNAL OF MICROSCOPICAL SCIENCE.

PLATE I.

Illustrates Mr. Gorham's Paper.

DESCRIPTION OF PLATE II.

Illustrating Mr. Currey's Paper.

Fig.

1.—A thread of *Trichia chrysosperma.*

2.—The end of a similar thread acted upon by sulphuric acid. The spiral appearance has vanished for a short space from the end.

3.—The end of a similar thread which had been soaked in oil of lemons. The tip appears to have become flaccid, and the spiral marking has partially disappeared.

4.—A thread of *Trichia nigripes.*

5.—A portion of a thread of *Trichia Neesiana,* acted upon by Schulz's solution.

6.—The tip of the same.

7 and 8.—Portions of threads of *Trichia serpula.*

9.—Portion of a thread of *Trichia pyriformis.*

10.—The membrane of *Trichia pyriformis,* unrolling spirally.

All the figures are highly magnified.

DESCRIPTION OF PLATE III.

In illustration of Dr. Allman's Paper.

Figs. 1—8. *Aphanizomenon Flos-aquæ.*

Fig.

1.—Fascicles of filaments, natural size.

2.—Three primary fascicles united into a larger bundle, magnified.

3.—The fascicles have broken up into their component filaments, which have rearranged themselves into parallel wavy curves, slightly magnified.

4.—A filament with two sporangia.
a, a, ordinary cells.
b, b, sporangia.

5.—A filament with a heterocyst.
a, a, ordinary cells.
b, b, heterocyst.

6.—Filament with a heterocyst after the application of a solution of iodine.
a, ordinary cells.
b, heterocyst.

7.—A sporangium after the application of a solution of iodine.

8.—Portion of a filament in which several ordinary cells seem to be in process of coalescence, in order to form a sporangium.

Figs. 9—17. *Peridinea uberrima.*

9.—*P. uberrima* in the act of swimming, viewed from the side of the vertical furrow. The ocelliform spot and nucleus are visible through the walls.

10.—The same viewed from the opposite side.

11.—The animalcule after having passed from a motile to a quiescent state.

12.—The animalcule with the external vesicle ruptured, and the contents escaping.
a, a, oil-globules.
b, nucleus.
c, c, brown granules.

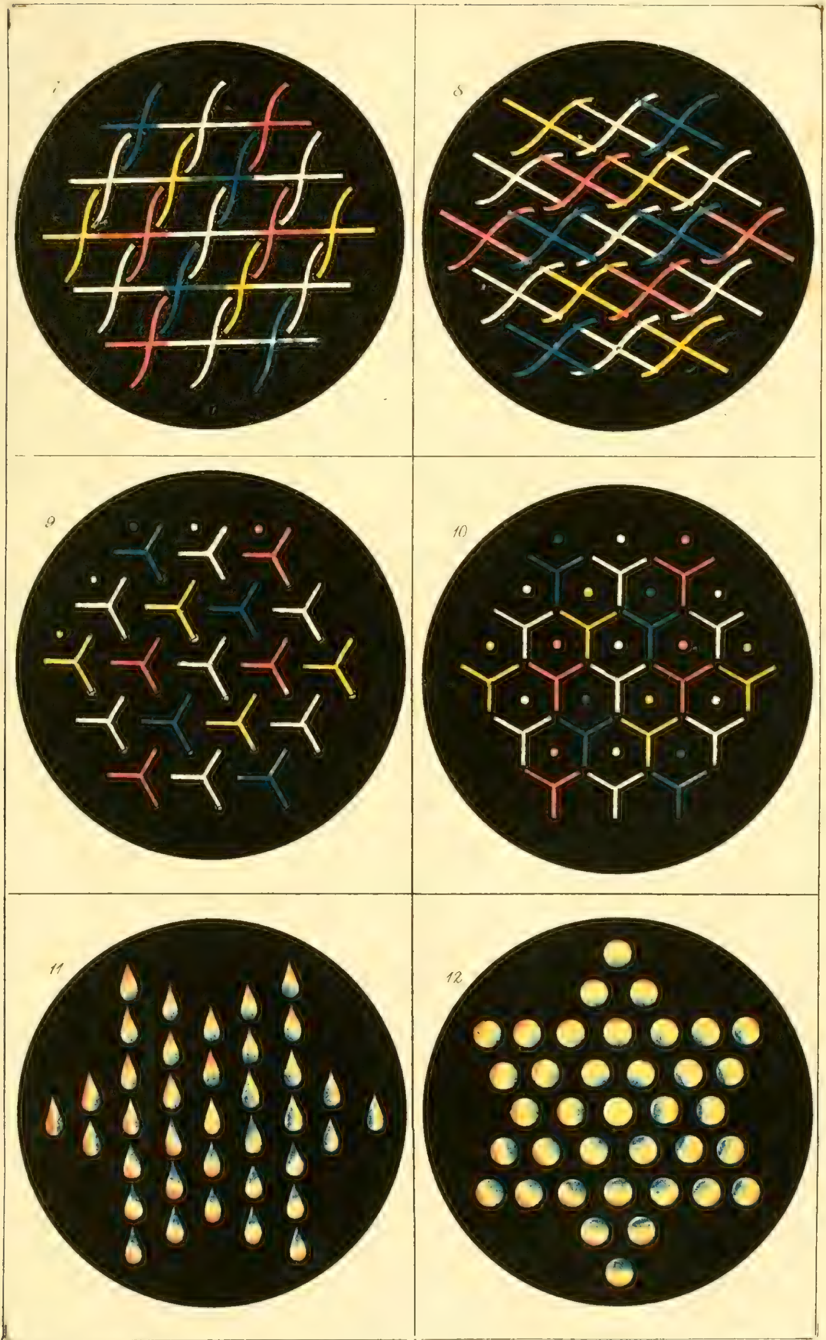
13.—The nucleus isolated.

14.—The animalcule undergoing transverse division.

15.—The same after the application of a solution of iodine.

16.—Outline of nucleus, with commencement of transverse division.

17.—Transverse division nearly completed.



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DESCRIPTION OF PLATE IV.

Illustrating Prof. Gregory's Paper on the Glenshira Sand.

Fig.

1.—*Eunotia Falx*, n. sp.
(Found in the deposits of Lüneberg and Lillhaggsjön. See Vol. II., p. 104, of this Journal.)

2.—*Nitzschia Sigmatella*, n. sp.
(Found as above, but also in the Mull deposit, and, with all the following figures, in the Glenshira sand.)

3.—*Cymbella truncata*, n. sp.

4.—*Amphora Arcus*, n. sp.

5.— „ *incurva*, n. sp.

6.— „ *angularis*, n. sp.

7.—*Cocconeis transversalis*, n. sp.

8.— „ *speciosa*, n. sp.

9.— „ *distans*, n. sp.

10.— „ *costata*, n. sp.

11.—*Eupodiscus Ralfsii?* var.

12.—*Surirella fastuosa*, var.

13.—*Tryblionella constricta*, n. sp.

14.—*Amphiproa Vitrea*, var.?

15.—*Navicula birostrata*, n. sp.

16.— „ *rhombica*, n. sp.

17.— „ *gastroides*, n. sp.

18.— „ *crassa*, n. sp.

19.— „ *maxima*, n. sp.

20.—*Pinnularia Gastrum*, *Ehr.*

21.— „ *apiculata*. n. sp.

22.—*Synedra Vertebra*, n. sp.

23.— „ *undulans*, n. sp.

DESCRIPTION OF PLATE V.

Illustrating Mr. Huxley's Paper on Noctiluca.

Fig.

1.—*Noctiluca miliaris*, from above.

2.– The animal viewed from behind, showing the groove.

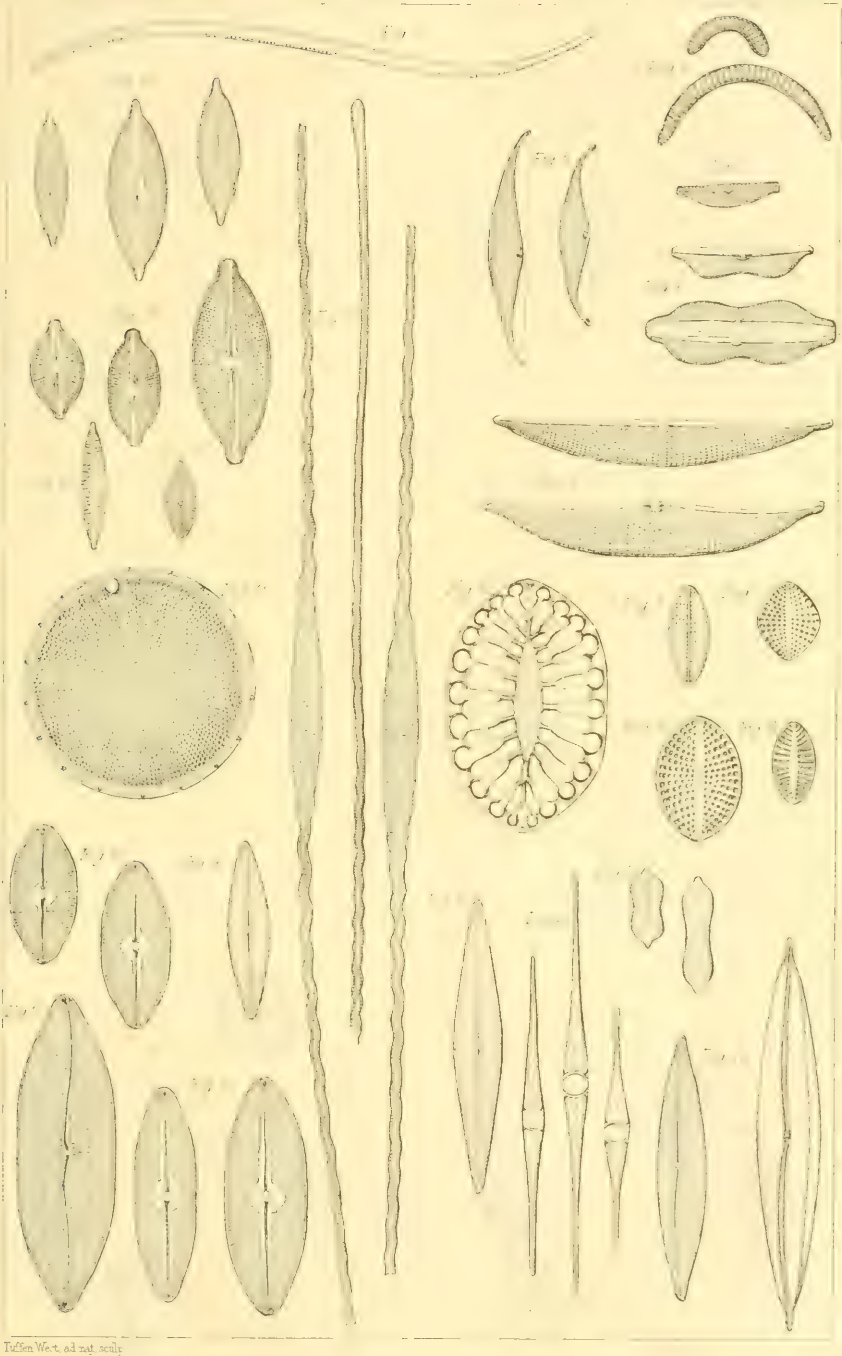
3.—A latero-inferior view, displaying the oral aperture, the cilium, the tooth, a gastric pouch, and the anal (?) aperture.

4.—The oral aperture on a larger scale.

5.—Antero-superior view, showing the nucleus, the fibres and fibrils, the tooth and the reproductive (?) granules.

6.—The superficial network of granules and fibrils.

a, Tentacle. *b*, groove. *c*, nucleus. *d*, tooth. *e*, gastric pouches. *f*, anal aperture. *g*, radiating fibres and fibrils. *h*, reproductive (?) granules.



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DESCRIPTION OF PLATE VI.,

Illustrating Dr. Johnston's Paper on the Mosquito.

Fig.

1.—Head of male mosquito, magnified 20 diameters.

2.—Orbital rings supporting the capsules.

3.—Auditory capsule (sectional view).

4.—Two joints of antenna.

5.—Diagram of auditory (?) and antennar nerve.

DESCRIPTION OF PLATE VI.,

Illustrating Dr. Webb's Paper.

Fig.

6.—Is a side view of the *Noctiluca miliaris*. The conical appearance of the tooth is seen in this position.

7.—A front view of the same parts. *a*, the outer surface of "the tooth;" *b*, the oral aperture; *c*, position of the supposed anal aperture.

8.—View in profile of the central depression.

9.—Sectional view of the central depression and tooth, from behind.

10.—The nucleus enveloped in a membrane with yelk-like matter.

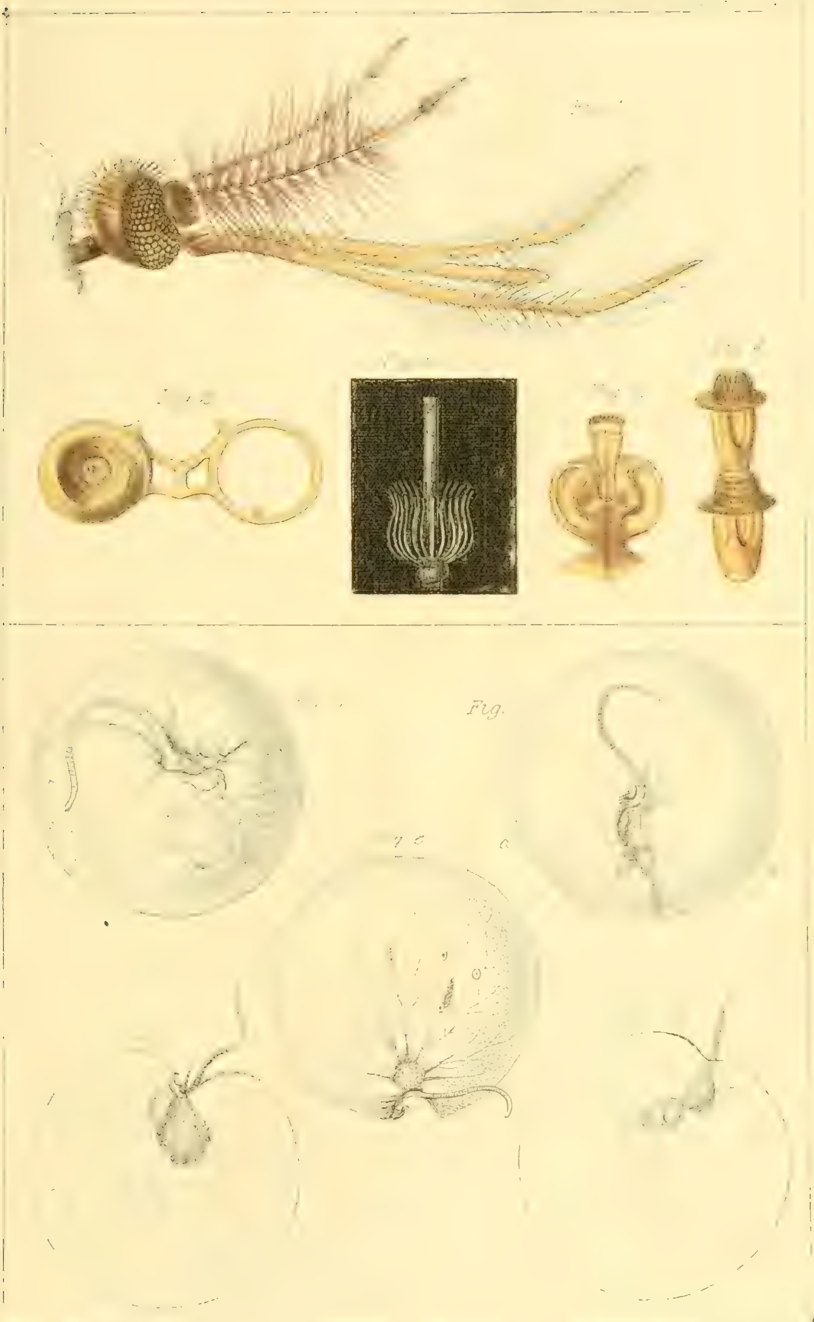


Fig.

EXPLANATION OF THE PLATES

Illustrating Dr. Redfern's Paper.

The drawings from which the Plates were executed were made by the camera lucida, under a power of 140 linear diameters. Scales having reference to the different figures are appended to each Plate. The whole of the figures in Plates VII. VIII. and the first four in Plate IX. are represented in the lithographs as magnified 180 diameters. Figs. 5 and 6 of Plate IX. are only enlarged 50 diameters, and have a separate scale below them.

PLATE VII.

Fig.

1.—Horizontal section of Torbanehill coal, 2 inches from the top of the seam, showing a three-lobed yellow patch with its radiate lines, and a mass of substance in which the yellow matter is imperfectly marked out into rounded or angular spaces by darker bands.

2.—Vertical section at the same part, showing irregularly elongated yellow and reddish patches, bounded by dark lines, running in the direction of the laminæ of bedding; also a crystal, which polarises light very powerfully.

3.—Horizontal section of the same block of coal 16 inches from the top, showing irregularly rounded yellow bodies with dark outlines; much smaller polygonal spaces of more uniform size; and a section of a rounded vegetable capsule like a spore.

4.—Vertical section at the same part as the last, showing the yellow bodies elongated in the direction of the laminæ of bedding, with their dark-brown boundaries projecting at the free edge, like pieces of membrane or fibre.

5.—Horizontal section, and 6, vertical section, of Wemyss coal, showing yellow bodies with radiate lines, similar to those in the Torbanehill coal, and like them rounded on horizontal sections and elongated on vertical ones.

PLATE VIII.

1 and 2.—Horizontal and vertical sections of Methill coal.

3 and 4.—Horizontal and vertical sections of Capledrae coal, showing, as well as the sections of Methill coal, similar yellow bodies to those in the Torbanehill coal, rounded on horizontal sections, and elongated in the direction of the laminæ of bedding on vertical sections.

5.—Shows spherical or polygonal membranous capsules, tubercular or pilose on the surface (spores?), found in great numbers on all thin horizontal sections of Torbanehill coal.

6.—Similar bodies seen on vertical sections of the same coal.

PLATE IX.

TORBANEHILL COAL.

1.—Scalariform tissue abundant in the Stigmariæ.

2.—Horizontal section, showing the action of heat on the upper edge of the section.

3.—Vertical section, showing the relation which exists between dense masses of vegetable tissue and the general structure of the coal.

4.—Horizontal section, showing what appear to be bands of fibre with a reticulate arrangement.

5.—Vertical section passing through what appears to be a membranous capsule, tubercular or hairy on the external surface, and smooth within.

6.—Horizontal section, showing another view of a similar body to the last.

Fig. 1

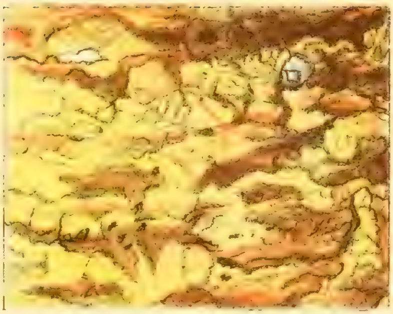


Fig. 3

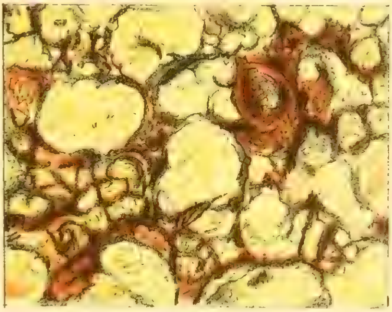


Fig. 4

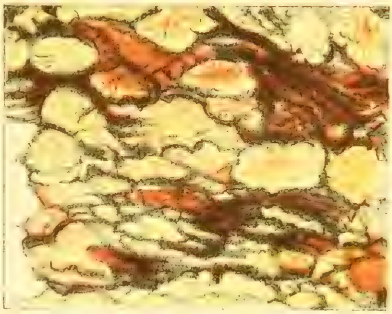
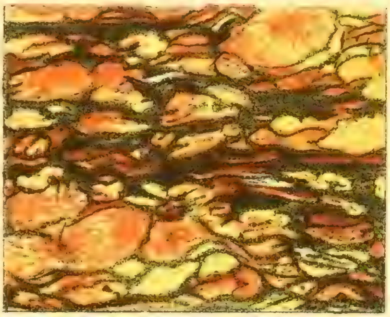


Fig. 5



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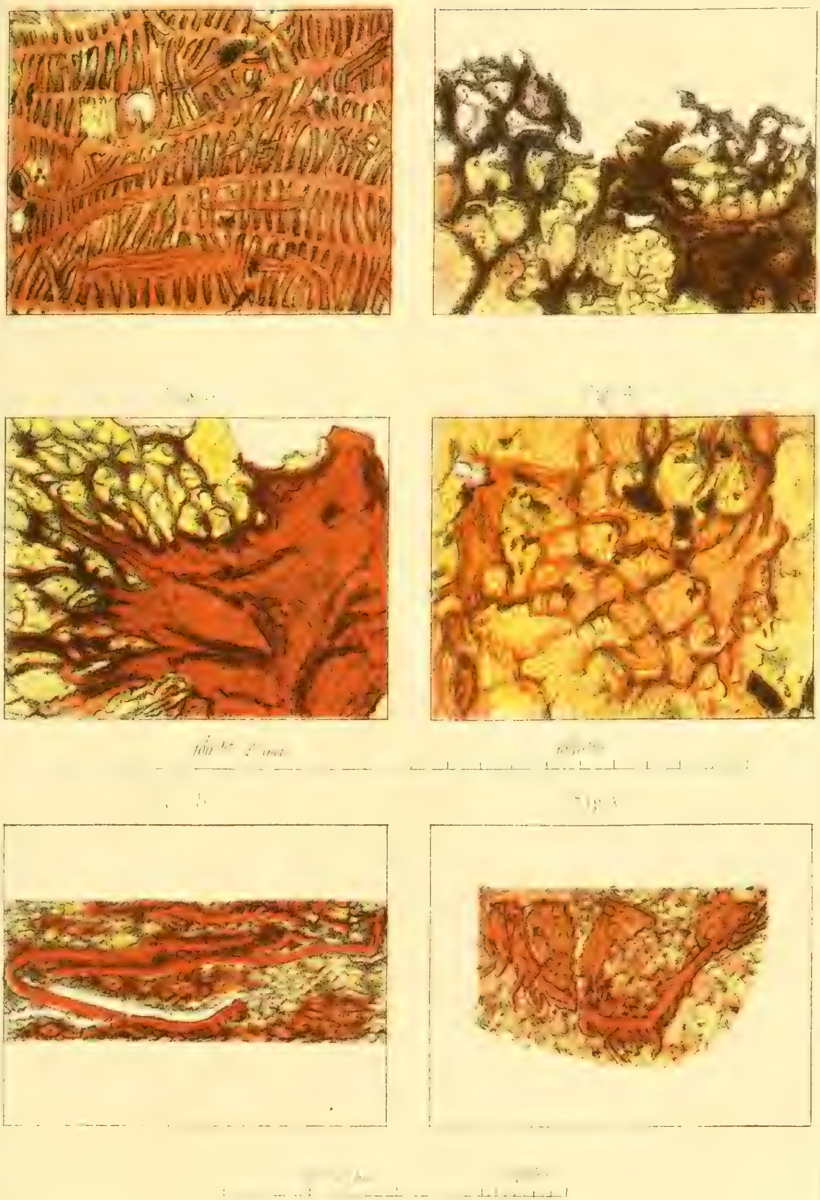


EXPLANATION OF PLATE X.

Figures illustrating Dr. Busch on *Noctiluca.*

Fig.

1.—*Noctiluca punctata*, Busch (*miliaris*, E. and G.). *a*, border turned in at the *hilus; b*, sharp bordered rod; *c*, brown body (*nucleus*, Quatref.); *d*, *proboscis; f*, brown corpuscles seen in the interior.

2 and 3.—Germs of *Noctilucæ* found in empty *sacculi.*

4.—Farther development of the germ. *c*, brown body (*nucleus*); *d*, *proboscis.*

5 and 6.—Young *Noctilucæ. b*, rod; *c*, brown body (*nucleus*); *d*, *proboscis.*

7.—Monstrous *Noctiluca.*

8.—The granular body from the interior of the *Noctiluca* (fig. 1 *f*) highly magnified.

9.—Luminous discs found among the *Noctilucæ.*

10.—The minute bodies seated on the upper border of these discs.

Figures illustrating Dr. Allman's Paper.

11.—*Bursaria leucas*, Ehr., magnified about 90 diameters.

a. Nucleus.
b. Contractile space.
c. Digestive vacuole filled with food.
d. Mouth.

12.—Ideal Section of *Bursaria leucas.*

a. Nucleus.
e. Dermal layer containing trichocysts, and covered with cilia.
f. Green globules forming a distinct stratum beneath the dermal layer.
g. Granular colourless contents.

13.—A portion of the outline of the animal after the application of acetic acid. The trichocysts have become changed into long acicular bodies, some of which radiate from the surface, to which they still partially adhere, while others are scattered over the stage of the microscope.

14.—A greatly enlarged view of the margin, to show the position of the trichocysts.

f. Green globules.
g. Granular contents.
h. Trichocysts.
i. Cilia.

15.—Isolated trichocysts in a quiescent state.

16.—First stage of evolution—the trichocysts have become transformed into spherules.

17.—Second stage of evolution—the spherules are replaced by a spiral filament, which rapidly unrolls.

18.—Final stage of evolution—the completely unrolled filament lies as a transparent spiculum in the field of the microscope.

k. Spicula with a filiform appendage at one extremity.
l. Spicula without the filiform appendage.

JOURNAL OF MICROSCOPICAL SCIENCE.

ZOOPHYTOLOGY.

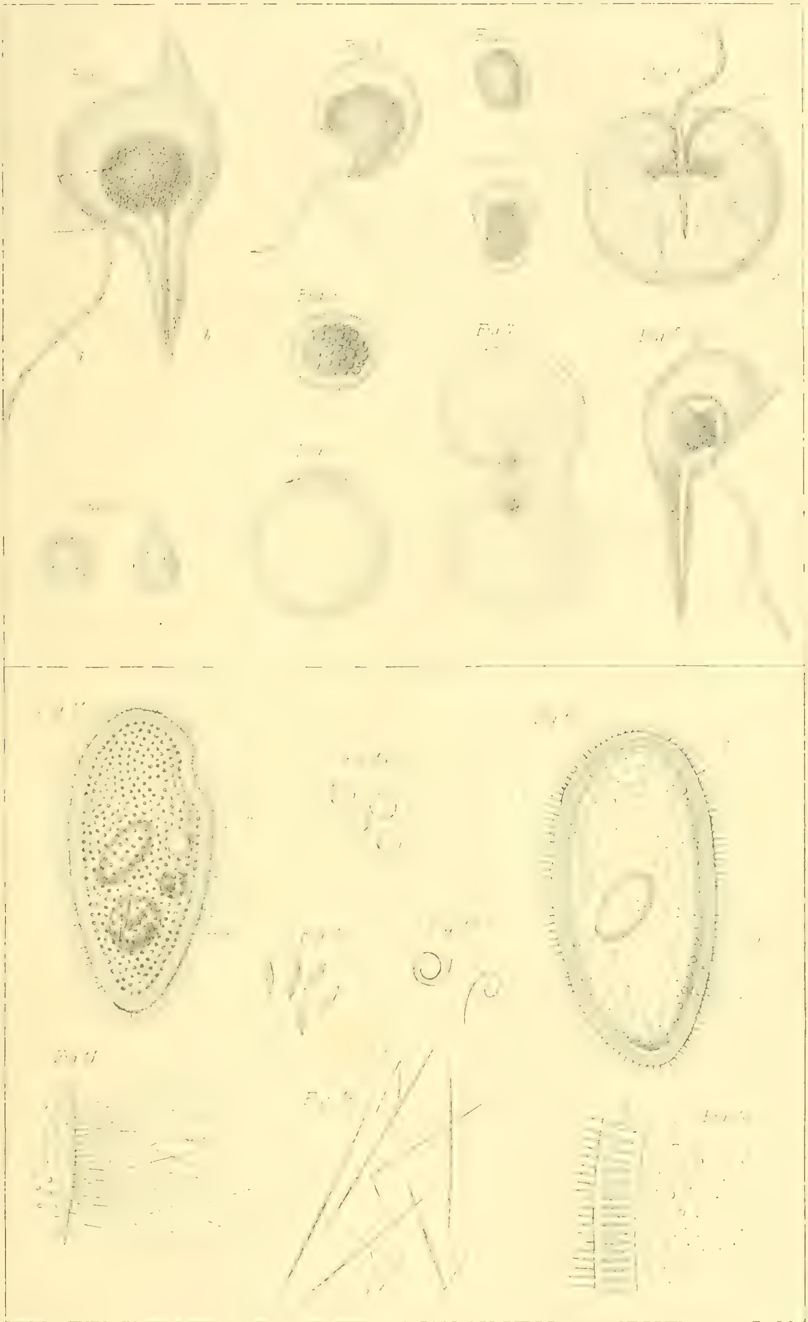
Description of Figures.

PLATE I.

Fig.
1.—*Salicornaria borealis* (natural size.)
2.—The same, magnified about 40 diam.
3.—The same, magnified about 80 diam.
4.—*Menipea arctica*, magnified about 40 diam.
5.—Front view of a cell, with avicularium, magnified 80 diam.
6.—Back view of part of a branch, magnified about 80 diam.
7.—*Membranipora Sophiæ*, magnified 80 diam.

PLATE II.

1.—*Lepralia scutulata*, magnified 40 diam.
2.—The same, magnified 80 diam.
3.—*Tubulipora ventricosa*, magnified 40 diam.
4.—Extremities of two tubes magnified about 80 diam.
5.—*Sertularia polyzonias ?* (natural size.)
6.—The same, magnified about 40 diam.
7.—*Sertularia imbricata* (natural size.)
8.—The same, magnified about 40 diam.
9.—The same, magnified about 80 diam.



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DESCRIPTION OF PLATE XI.

Illustrating Mr. Rainey's paper on the Structure of the Cutaneous Follicles of the Toad.

Fig.

1.—Skin of toad injected, showing cutaneous capillaries.

2.—Opposite side of the same piece of skin, showing one of the cutaneous follicles.

3.—A vertical section of the skin, showing some follicles cut perpendicular to the surface.

a. One cut at its middle, where it communicates with the surface.

b. b. Follicles cut on one side of their centre.

c. A layer of earthy matter lying over the follicle, between it and the surface.

These three are magnified 20 diameters.

4.—Horizontal section of a follicle, showing the folds of internal membrane.

a. The layer of capillaries.

b. Internal membrane.

c. Epithelium covering the follicles of the internal membrane.

Magnified 50 diameters.

5.—A. Deep portion of the epidermis, showing the form of the epidermic scales, and the clear, homogeneous nuclei.

B. Epithelium of a cutaneous follicle, showing the character of the epithelic cells and the granular nuclei, with some of the granular contents of the follicle.

Magnified 300 diameters.

DESCRIPTION OF PLATE XII.

Illustrating Mr. Currey's paper on the reproductive organs of Fungi.

Fig.

1.—A perithecium of the sphæropsoid form of *Sphæria herbarum* with its mycelium, attached to a fragment of the cuticle of a dead stem of *Senecio Jacobæa*, magnified about 110 diameters.

2.—Transverse section (magnified 110 diameters) of a similar perithecium, showing the spermatia in its interior. The knotty mycelium is still attached.

3.—Reproductive gemmæ, or conidia, which grow directly from the mycelium of *Sphæria herbarum*, magnified 220 diameters.

4.—An ascus and sporidia of *Sphæria herbarum*. The sporidia have germinated in the interior of the ascus, and have broken through the membrane. Magnified 220 diameters.

5 and 6.—Germinating sporidia of *Sphæria herbarum*. In fig. 5 are seen globular vesicles at the extremity of short lateral branches. Magnified 220 diameters.

7.—Fragment of a germ-filament of a sporidium of *Sphæria herbarum*. At the extremity of a short lateral branch a nucleus has been formed, and a fresh germ-filament thrown out.

8.—A germinating sporidium of *Sphæria herbarum*, showing the formation of a lateral bud similar to those shown in fig. 3. Magnified 220 diameters.

9.—Asci and sporidia of *Sphæria herbarum*, magnified 220 diameters.

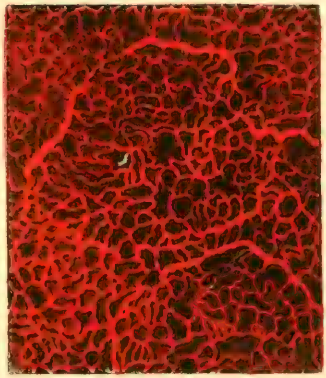
10.—Ascus and sporidia of *Sphæria* (*complanata?*), magnified 220 diameters.

11.—One out of a number of similar bodies found in the interior of the perithecia of *Sphæria complanata*, magnified 220 diameters.

12.—Young states of asci of *Sphæria Cryptosporii*, magnified 220 diameters.

13.—(*a*), perfect asci, with sporidia of *Sphæria Cryptosporii*. (*b*), a sporidium from one of the asci. (*c*), a very young ascus. (*d*), an ascus rather more advanced. (*e*), the most common form of spore of *Cryptosporium vulgare*. (*f*), another form of spore of the same plant. All magnified 220 diameters.

14.—Asci and sporidia of *Sphæria* found growing with *Cryptosporium vulgare*, magnified 220 diameters.



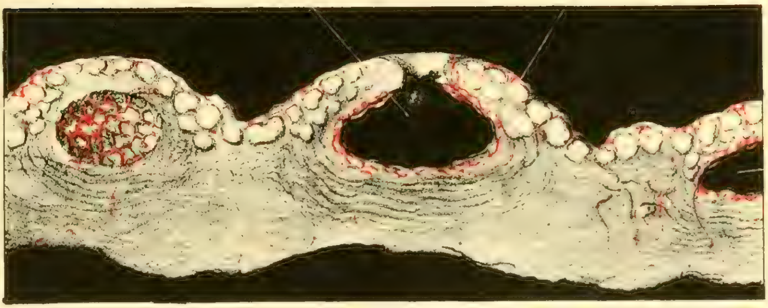
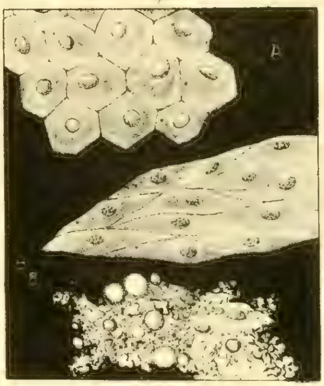


Fig. 4

Fig. 5



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PLATES XIII. AND XIV.

Figures illustrating Mr. J. Glaisher's Paper on Snow Crystals.

Figs. 14 and 19 are not referred to in the paper: on these Mr. Glaisher adds the following notes:—

FIG. 14.—*On February 8th*, the mean reading of the barometer at the height of 82 feet above the sea was 29·730 inches: the highest reading of the thermometer during the day was 32°, the lowest was 27¾°, and the mean temperature for the whole day was 30°, being 8° below the average of the same day. The temperature of the dew point was 29°. Snow was falling the whole of the day, with scarcely any intermission.

FIG. 19.—*On February 17th*, the mean reading of the barometer at the height of 82 feet was 29·880 inches: the highest reading of the thermometer during the day was 33¼°, the lowest was 22°, and the mean for the whole day was 25½°, being 13½° below the average for the day. The mean temperature of the dew point was 19½°. The sky was overcast till noon, and snow was falling occasionally.

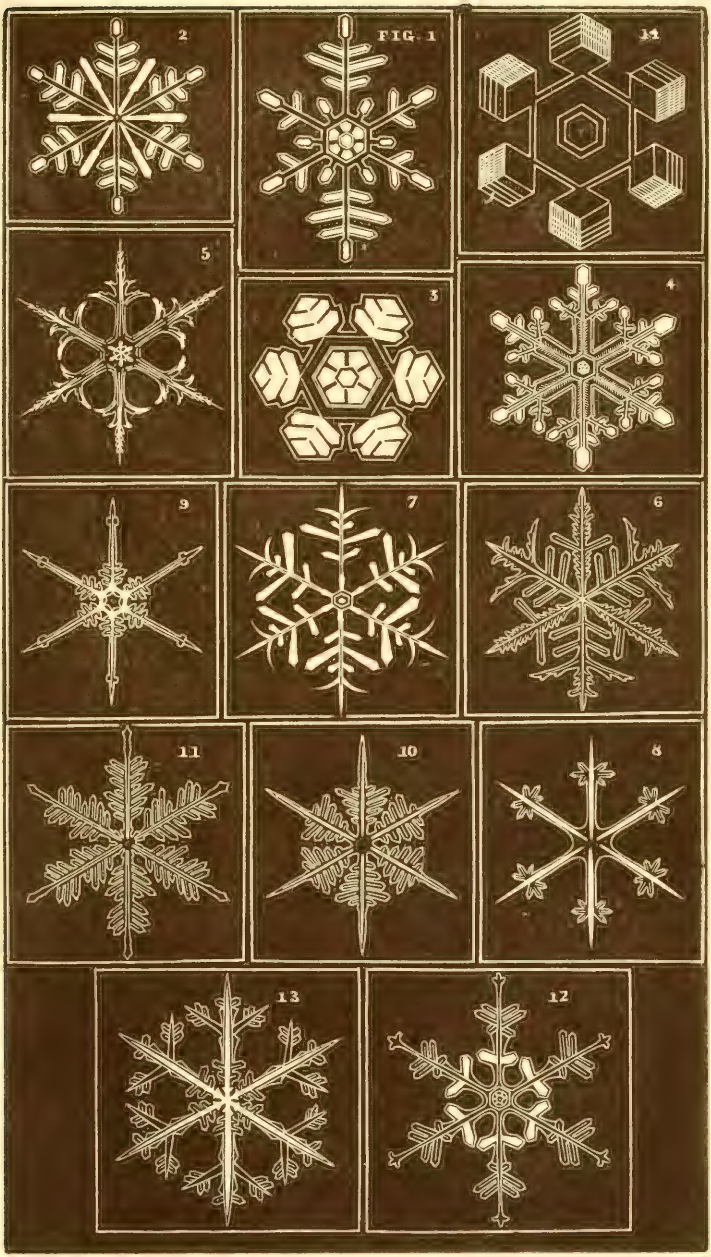
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FIG. 1
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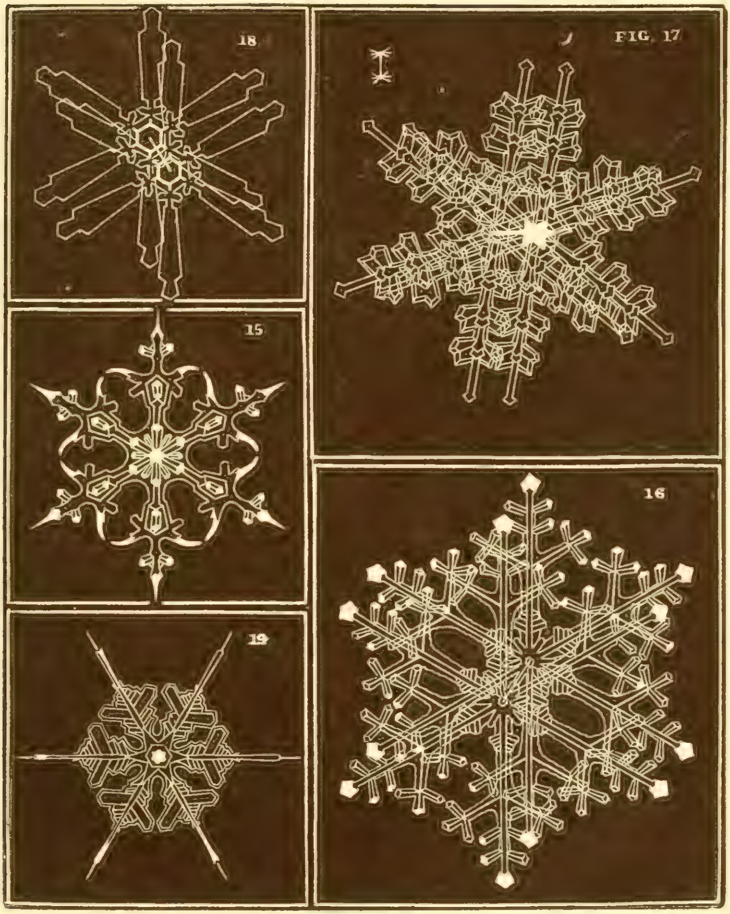
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FIG. 17
15
16
19

Plate I.

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Plate II.

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ZOOPHYTOLOGY.

DESCRIPTION OF FIGURES.

Plate III.

Fig.

1.—Portion of polyzoary of *Onchopora hirsuta* in the younger condition.

2.—Ditto, older.

3, 4, 5.—Disposition of the cells at an articulation.

6.—Natural size.

Plate IV.

1.—Portion of polyzoary of *Onchopora tubulosa.*

1 (*a*).—Natural size.

2, 3.—*O. mutica.*

3 (*a*).—Natural size.

4.—*Eschara cervicornis?* in the younger part of the polyzoary.

5.—An older portion.

6.—One still older, in which the cells are quite immersed.

7.—Natural size.

Plate III

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